

**Fina Oil and Chemical**

**Calumet City, IL**

**ENSR**

**Risk Assessment for Fina Oil  
and Chemical/Cosden  
Chemical Facility  
Calumet City, Illinois**

**ENSR Consulting and Engineering  
(Formerly ERT)**

**June 1990**

**Document Number 9500-058-320**

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## 1.0 INTRODUCTION

The objective of this report is to present the results of the evaluation the potential of health effects of chemicals found in soil and groundwater at the Fina Oil and Chemical, Cosden Chemical Division, facility (Fina facility) in Calumet City, Illinois. The portions of the site to be evaluated; the former polystyrene blowdown area, the styrene monomer storage area, and areas of soil near manholes at the site, represent areas where chemicals may be present in soil. The evaluation of these areas of the site combines data from a number of previous samplings. The potential health effects of chemicals found in groundwater at the site will also be evaluated.

The approach used to evaluate the potential risk of adverse health effects from chemicals in these areas is to conduct a baseline human health risk assessment using the method recommended in the United States Environmental Protection Agency's (U.S. EPA's) Risk Assessment Guidance for Superfund (RAGS) (U.S. EPA, 1989a).

### 1.1 Site Description

The Fina facility, which manufactures polystyrene, is located in an industrial area at Paxton Avenue and 142nd Street in Calumet City, Illinois. A piece of land directly opposite the facility to the south is zoned industrial/residential and is currently unused. The Fina facility is bordered by the Little Calumet River to the north (see Figure 1-1), by Ashland Oil Company to the east, and by highway I-94 to the west.

### 1.2 Field Investigation

ENSR Constructors has undertaken remedial investigations to determine whether chemicals used at the facility have been released to soil and groundwater in the site area. In June 1989, ENSR Constructors issued a report on sampling investigations and remediation at the former styrene blowdown area. The report is included as Appendix A. The area was remediated by removing soil, from the surface to a depth of 4 feet, and backfilling the remediated area with clean fill. Following remediation, traces of chemicals remained at depth. These investigations examined soil for benzene, toluene, ethylbenzene, xylene and styrene.

ENSR Constructors has also investigated soil near manhole covers leading to a sewer that runs from the site. Fina uses the sewer system for sanitary sewage only. No process-related waters are released to the system by Fina. However, the sewer system is also used by Ashland Oil Company, located directly east of the Fina facility across Paxton Avenue, for sanitary sewage





and, potentially, for process waters. The system has been subject to backups caused by failures in the lift station, which is located where this sewer system joins the municipal system. Because of the backups, chemicals from Ashland Oil Company could potentially have been released onto Fina property. This investigation examined soil for a larger number of chemicals as shown in Section 2.0.

In February 1990, sampling of soil in the areas around the manholes was undertaken by ENSR Constructors to determine potential chemical concentrations in the soil. The report of this sampling investigation is included as Appendix B.

In addition, ENSR subcontracted with Fox Drilling, Inc. (Fox), of Itasca, Illinois, to advance 16 soil borings ranging in depth from 8 to 15 feet below ground surface. The borings, designated MW-4A, SS-4A, SS-5A, SS-10A, SS-10B, SS-13A, SS-14A, SS-14B, SS-15A, SS-15B, SS-16A, SS-16B, SS-17A, and SS-17B, were drilled between March 27, 1990, and March 30, 1990. Because of access problems, borings SS-11A and SS-12A were hand augered on April 12, 1990. Boring locations are presented in Figure 1-1. The investigation examined soil for benzene, toluene, ethylbenzene, xylenes, and styrene as reported in Appendix C.

After the equipment and tools used for drilling the borings had been thoroughly steam cleaned, Fox began drilling a monitoring well at the location designated MW-4A. All borings were advanced using a hollow-stem auger and were terminated when silty clay was encountered, typically 8 to 10 feet below the ground surface.

Soil samples were collected above and at the water table for laboratory analysis. The depth to the water table at the site ranged from 2 feet to 4 feet below the ground surface. Each soil sample collected was analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) and for styrene using U.S. EPA Method SW-846: 8020 (U.S. EPA, 1986), and for formaldehyde using National Institute of Occupational Safety and Health (NIOSH) Method 3500 (NIOSH, 1984). The March 1990 soil sampling results are documented in ENSR Constructors' report of May 1990 (Document No. 9500-058-340), attached as Appendix C, and summarized in Table 1-1.

Groundwater samples were collected from monitoring well MW-4A and MW-3 through MW-7 and analyzed for benzene, toluene, ethylbenzene, BTEX, and styrene using EPA Method SW-846: 8020 and for formaldehyde using NIOSH Method 3500. A field blank was collected to ensure that correct decontamination procedures had been followed. A duplicate groundwater sample (MW-4B) was also collected from MW-4 to provide a quality check of laboratory analysis. The groundwater sampling results are summarized in Table 1-2.

TABLE 1-1  
Summary of Soil Sampling Results<sup>1</sup>  
Fina Chemical Company

Parameter	14B/ 1.5-2R	14B/ 6.5-7R	14B-1/ 1.5-2R	14B-1/ 6.5-7R	17A/ 2.5-2.9R	17A/ 8.5-9R	17B/ 2.5-3R	17B/ 7-7.5R	18A/ 3-3.5R	18A/ 6.5-7R	18B/ 3-3.5R	18B/ 6.5-7R	18B/ 9-9.5R	18B/ 10B/ 9-9.5R
Benzene	<125 <sup>2</sup>	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125
Ethylbenzene	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125
Toluene	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125
Xylene	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125
Styrene	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125	<125
Benzene	13A/ 2-2.5R	13A/ 7.5-8R	5A/ 1.16R	5A/ 1.16R	4A/ 1-1.5R	4A/ 5.5-6R	Trip Blank <sup>3</sup>	Equip. Blank <sup>4</sup>	MW-4A/ 1-3R	MW-4A/ 6-7R	15A/ 3.5-4R	15A/ 8-9R	15A/ 8-9R	15A/ 8-9R
Ethylbenzene	<125	<125	<125	<125	<125	<125	<1	<1	<125	<125	<125	<125	<125	<125
Toluene	<125	<125	<125	<125	<125	<125	<1	<1	<125	<125	<125	<125	<125	<125
Xylene	<125	<125	<125	<125	<125	<125	<1	<1	<125	<125	<125	<125	<125	<125
Styrene	8500	8700	<125	<125	<125	<125	NA	NA	<125	<125	<125	<125	<125	<125
Formaldehyde	NA <sup>5</sup>	NA	NA	NA	NA	NA	NA	NA	0.125	<0.100	NA	NA	NA	NA
Benzene	15B/ 1.5-2R	15B/ 4-4.5R	10A/2 5-3R	10A/ 8-8.5R	10B/ 3-3.5R	10B/ 8-8.5R	14A/ 3.5-4R	14A/ 7.5-8R	Trip Blank <sup>3</sup>	Equip. Blank <sup>4</sup>	12A/ 1.5-2R	12A/ 5-6R	12A/ 5-6R	12A/ 5-6R
Ethylbenzene	<125 <sup>4</sup>	<125	<125	<125	<125	<125	<125	<125	<1	<1	<125	<125	<125	<125
Toluene	<125	<125	<125	<125	<125	<125	<125	<125	<1	<1	<125	<125	<125	<125
Xylene	<125	<125	<125	<125	<125	<125	<125	<125	<1	<1	<125	<125	<125	<125
Styrene	<125	<125	<125	<125	<125	<125	<125	<125	NA <sup>5</sup>	NA	<125	<125	<125	<125

TABLE 1-1

Summary of Soil Sampling Results<sup>1</sup>  
Fina Chemical Company

Parameter	11A/ 2.5-3ft	11A/ 4.5-5ft	11B/ 2.5-3ft	11B/ 4.5-5ft
Benzene	<125	<125	<125	<125
Ethylbenzene	<125	<125	<125	<125
Toluene	<125	<125	<125	<125
Xylene	<125	<125	<125	<125
Styrene	<125	<125	<125	<125

<sup>1</sup> BTEX and styrene concentrations reported in parts per billion =  $\mu\text{g}/\text{kg}$ , formaldehyde is reported in ppm =  $\text{mg}/\text{kg}$ .

<sup>2</sup> < indicates concentration below the method detection limit. The number following the < is the detection limit.

<sup>3</sup> Trip blank.

<sup>4</sup> Equipment blank.

<sup>5</sup> NA = Not analyzed.

TABLE 1-2

Summary of Groundwater Analytical Results<sup>1</sup>  
Fina Chemical Company

Parameter	MW-4A	MW-4B <sup>2</sup>	MW-7 Old	MW-6 Old	E.B. <sup>3</sup>	MW-5 Old	MW-4 Old	T.B. <sup>4</sup>	MW-3 Old	T.B.	F.B. <sup>3</sup>
Benzene	<1 <sup>5</sup>	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene	<1	<1	<1	<1	<1	<1	30	<1	<1	<1	<1
Toluene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.1
Xylene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Formaldehyde	<0.025	0.038	0.068	0.042	0.055	0.183	0.033	NA <sup>6</sup>	0.439	NA	NA
Styrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

<sup>1</sup> BTEX and styrene concentrations reported in parts per billion (ppb) =  $\mu\text{g/L}$ . Formaldehyde concentrations reported in parts per million (ppm) = mg/L.

<sup>2</sup> Duplicate of sample NW-4A.

<sup>3</sup> Equipment Blank/Field Blank.

<sup>4</sup> Trip Blank

<sup>5</sup> < indicates concentration below the method detection limit. The number following the < is the detection limit.

<sup>6</sup> NA = Not analyzed.

All samples were collected using ENSR's Standard Operating Procedures (SOPs) and sent to ENSR's Houston, Texas, laboratory under chain-of-custody procedures for analysis.

### **1.3 Risk Assessment Methodology**

Because the Fina facility is currently operating, and Fina officials plan to continue operating the plant as an industrial facility for the foreseeable future, only potential industrial exposure scenarios will be considered. Therefore, on-site workers comprise the potentially exposed population assumed in this evaluation. The human health risk assessment will follow the four steps identified in RAGS:

- Identification of chemicals of potential concern
- Exposure assessment
- Toxicity assessment
- Risk characterization

A brief description of each step is given below.

#### **1.3.1 Identification of Chemicals of Potential Concern**

In the first step of the risk assessment process, the analytical data available concerning the site is gathered, analyzed, and organized into a form appropriate for evaluating human health risk. First the distribution of chemicals is assessed. This assessment involves the definition of the representative range of chemical concentrations and the frequency with which chemicals were detected. Data regarding site-related chemical concentrations are then combined with information related to the chemical's toxicities to rank them according to toxicity potential. This ranking may be modified based on other properties that may affect a chemical's environmental mobility and persistence. Finally, chemicals of potential concern are selected based on their high ranking for potential noncarcinogenic and/or carcinogenic health effects. As stated earlier, each soil and groundwater sample collected was analyzed for BTEX, styrene, and formaldehyde. For the purpose of this risk assessment, a conservative approach, using the highest chemical concentrations found at various locations, will be adopted. The assessment will therefore tend to overestimate risk at the facility.

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### **1.3.2 Exposure Assessment**

The second step in the risk assessment process, exposure pathways and potential chemical exposure concentrations are evaluated.

An exposure pathway is defined as a mechanism by which an individual or population is potentially exposed to chemicals that originated from a source. Each pathway represents a different mechanism for exposure. As described in RAGS, there are generally four elements that must be present in order for a potential exposure pathway to be complete:

- A source and mechanism of chemical release into the environment;
- An environmental transport mechanism (e.g., air, soil, water);
- An exposure point or point of potential contact with the medium; and
- A receptor (e.g., human) with a chemical route (e.g., ingestion) at the point of contact.

Once a complete exposure pathway is identified, a potential chemical exposure concentration can be estimated. The estimated chemical concentration can then be used to estimate risk from the site. To evaluate an exposure pathway, scenarios can be constructed using a number of assumptions. This risk assessment uses conservative assumptions for worker's actions at the site, such as the inadvertent ingestion of and dermal contact with soil. Other exposure scenarios, such as the consumption of groundwater and the inhalation of air containing volatile organic compounds (VOCs), will not be evaluated because they are not considered to be complete pathways. This assumption is explained further in the exposure assessment section (3.0) of this report.

### **1.3.3 Toxicity Assessment**

In the third step in the risk assessment process, the relationship between exposures to a given chemical and the potential adverse health effects associated with exposure to that chemical are documented. In general, the data on adverse effects associated with direct exposure of humans to a particular chemical are limited. Often, animal experiments have been performed to assess a chemical's toxicity. These experiments are conducted to determine the toxic response a chemical may cause and the amount of chemical needed to elicit that response. This is known as the dose-response relationship.

In risk assessment, chemicals are generally considered to have two types of potential effects: carcinogenic (cancer-causing) and noncarcinogenic. Noncarcinogenic effects, such as liver or kidney damage, may be either self-repairing or permanent. There is a level of exposure at which these chemicals produce no adverse effects in the human body; in other words, they exert their toxic effect via a threshold mechanism.

Potential carcinogenic chemicals have been shown, or are suspected, to produce tumors in animals and/or humans. No threshold of effect is assumed to be associated with the carcinogenic effects of these chemicals.

Section 4.2 contains toxicological properties for each of the chemicals of potential concern identified at the Fina site and provides U.S. EPA dose-response relationship. These estimates are used later in the risk characterization process. For noncarcinogens, the reference dose (RfD), a dose believed to be below the threshold for adverse noncarcinogenic health effects, is identified. For carcinogens, the slope factor (SF), which will be used to estimate carcinogenic risk posed by a given dose of a chemical, is identified.

#### **1.3.4 Risk Characterization**

The fourth step of the risk assessment process combines dose-response information with estimates of human exposure in order to derive quantitative estimate of the likelihood that humans will experience any adverse health effects, given the exposure assumptions made. Two general types of risk are considered following chronic exposure: potential carcinogenic and potential noncarcinogenic risks.

The potential risks are estimated for each chemical of potential concern and for each exposure pathway. Risks are summed for each exposure pathway to give a total potential health risk for each receptor.

Risks for chemicals with noncarcinogenic effects and carcinogenic effects are considered, and summed, separately because of their assumed threshold and nonthreshold health effects.

## **2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN**

### **2.1 Chemicals of Interest**

A number of chemicals were detected above their detection limits during the three rounds of soil sampling conducted at the Fina facility. Summaries of chemicals detected at concentrations above their detection limits in soil are provided in Tables 2-1, 2-2, and 2-3 for each of the three sampling rounds.

### **2.2 Soil**

The highest chemical concentrations found in soil will be used in this risk assessment. Choosing the highest concentration for use in the assessment is a conservative approach because it is extremely unlikely that a worker at the site would contact only the highest chemical concentration in soil rather than a range of lower chemical concentrations. The assessment of risk from chemicals in soil will include the following chemicals: benzene, ethylbenzene, toluene, styrene, and phenol. These chemicals were selected based on their frequency of detection, toxicity, and mobility. Several other chemicals found at the site were not included in the risk assessment process. Acetone, polynuclear aromatic hydrocarbons (PAHs), and other chemicals were found at low concentrations near the manholes. Acetone was excluded because it does not have high toxicity and was not detected frequently at the site, only near manhole covers near the maintenance shop area. PAHs were excluded from the risk assessment because they are believed to originate from a background source, probably the railroad, and were not found throughout the site. Methylene chloride was excluded because it is a common laboratory contaminant. Methyl ethyl ketone and 4-methyl-2-pentanone were excluded because neither chemical has a high toxicity.

### **2.3 Groundwater**

Ethylbenzene was detected in one groundwater sample on-site, collected from monitoring well MW-4 (old) at a concentration of 30  $\mu\text{g/L}$ . Formaldehyde was detected in samples from seven monitoring wells at the site at concentrations ranging from 38  $\mu\text{g/L}$  to 439  $\mu\text{g/L}$ .

The appendices to this report contains details of sampling analysis and sampling locations. All the above chemicals were selected as potential chemicals of concern for evaluation in this assessment, in the interests of conservatism.



TABLE 2-1

Summary of Chemicals Found Above Detection Limits:  
First Sampling Round<sup>1</sup>

Parameter	Sample Point #1	Sample Point #2	Sample Point #3	Sample Point #4	Sample Point #5	Sample Point #6
Benzene	-	-	-	-	-	-
Toluene	-	-	(100)*	-	-	-
Ethylbenzene	3,600	47,000	10,000	1,200	2,000	(350)
Xylene	-	-	680	360	-	-
Styrene	-	-	3,100	-	1,400	15,000

<sup>1</sup> All units are in  $\mu\text{g}/\text{kg}$  of soil (ppb). Detection limits are 5  $\mu\text{g}/\text{kg}$  (ppb).

\* Estimated concentration.

- Below detection limit.

**TABLE 2-2**
**Summary of Chemicals Found Above Detection Limits:  
Second Sampling Round<sup>1</sup>**

Parameters	Sample S-1	Sample S-2	Sample S-3	Sample S-4	Sample S-5	Sample S-6	Sample S-7	Sample S-8	Sample S-9	Sample S-10
Acetone	490	1,600	170	190	18	-	-	190	18*	-
Ethylbenzene	9	-	-	-	-	-	-	-	-	-
Fluorotrichloro- methane	3*	3*	4*	4*	6	6	4*	13*	-	-
2-Hexanone	6	-	-	-	-	-	-	-	-	-
Methylene Chloride	-	35	-	-	6	4*	15	-	-	-
Methyl Ethyl Ketone	9*	12	-	-	-	-	-	-	-	-
4-Methyl-2-Pen- tanone	-	10*	-	-	-	-	-	-	-	-
Styrene	110	72	-	-	-	-	-	13*	-	-
Tetrachloroethene	-	-	-	-	-	-	4*	9*	24	-
Toluene	40	85	10	21	9	17	8	-	7	3*
Xylenes (total)	12	21	6	9	-	-	9	-	-	-
Ethyl Methyl Ben- zene	72	178	-	-	-	-	-	-	-	-
Anthracene	-	-	-	-	11,000*	-	-	-	-	-
Bis(2-ethylhexyl) Phthalate	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	14,000*	-	-	-	-	12,000
Fluoranthene	-	-	-	-	26,000	-	-	-	-	-

**TABLE 2-2**

**Summary of Chemicals Found Above Detection Limits:  
Second Sampling Round<sup>1</sup>**

Parameters	Sample S-1	Sample S-2	Sample S-3	Sample S-4	Sample S-5	Sample S-6	Sample S-7	Sample S-8	Sample S-9	Sample S-10
Phenanthrene	-	-	-	-	28,000	-	-	-	-	-
Pyrene	-	-	-	-	48,000	-	-	-	-	2,600*
Phenol	27,000	36,000	-	-	-	-	-	1,700	370*	12,000

<sup>1</sup>All values are in  $\mu\text{g}/\text{kg}$  (ppb).

\*Estimated concentration.

- Below detection limit.

TABLE 2-3

Summary of Chemicals Found Above Detection Limits:  
Third Sampling Round

Parameter	Sample Number										Frequency of Detection
	MW-4A 1-3ft	10B 3-3.5ft	16A 6.5-7ft	16B 3-3.5ft	16B 9-9.5ft	13A 2-2.5ft	13A 7.5-8ft	4A 1-1.5ft	15B 4-4.5ft	12A 1.5-2ft	
Benzene	-	140	-	-	-	-	-	-	-	-	1/16
Ethylbenzene	-	-	170	7,100	330	2,500	1,900	320	470	-	7/16
Toluene	-	-	-	-	-	-	-	-	-	440	1/16
Styrene	-	-	-	-	-	8,500	6,700	-	-	-	2/16
Formaldehyde	0.125 <sup>2</sup>	-	-	-	-	-	-	-	-	-	1/2

<sup>1</sup>Concentrations reported in  $\mu\text{g/kg}$  (ppb), except for formaldehyde.

<sup>2</sup>Concentration reported in  $\text{mg/kg}$  (ppm).

### **3.0 EXPOSURE ASSESSMENT**

#### **3.1 Introduction**

The objective of an exposure assessment is to establish realistic scenarios by which individuals or populations may be exposed to chemicals at a site. Once an exposure pathway has been established and found to be complete, an estimate of the extent of exposure to the chemicals of potential concern present at the site may be undertaken. Exposure assessments include the following three steps:

**1. Characterization of Exposure Setting**

- Physical environment
- Potentially exposed populations

**2. Identification of Exposure Pathways**

- Chemical source/release
- Exposure point
- Exposure route

**3. Quantification of Exposure**

- Estimate of exposure concentrations
- Estimate of intakes

By following these three steps, realistic scenarios for human exposure to the chemicals of potential concern for a hypothetically exposed individual are derived. The exposure assessment, based on a conservative evaluation of exposure in order to assess potential adverse human health effects, is likely to overestimate risk.

## **3.2 Characterization of Exposure Setting**

In evaluating exposure to chemicals in soil and groundwater at the Fina facility, the first step is to assess the site's physical characteristics and identify the human populations on and near the site. Following is a qualitative evaluation of the site and surrounding population with regard to characteristics that influence exposure.

### **3.2.1 Physical Environment**

The Fina facility is located at Paxton Avenue and 142nd Street in Calumet City, Illinois. Ashland Oil and Chemical Company is located directly across from Fina on Paxton Avenue to the east. Because the site contains a manufacturing facility, the exposure setting for this risk assessment is industrial. The site is bordered to the north by the Little Calumet River, to the south by a railroad, and to the west by the Calumet Expressway (I-94). No residences are currently located near the facility.

### **3.2.2 Potentially Exposed Population**

The Fina facility is used for manufacturing. Considering the current zoning, no potential exists for development of residential homes on-site. There is a potential for residential development on property located to the south, across the railroad from the Fina facility. However, because of the industrial nature of the surrounding area, residential development appears unlikely. Therefore, this risk assessment will focus on an industrial scenario for this site, and be confined to on-site worker exposure. Should zoning for the site change, and the facility be removed to make way for the development of residences on-site, this focus may need to be broadened or changed.

## **3.3 Characterization of Exposure Pathways**

The pathways by which the population at risk (on-site workers) may be exposed are examined during this step of the risk assessment. During this analysis, the sources, locations, and types of environmental releases are linked with population locations and activity patterns to determine the significant potential pathways of human exposure. Consideration is given to each potential exposure pathway (PEP) to ensure that all possible routes of exposure are accounted for in the final estimate of risk.

### **3.3.1 Identification of Chemical Source/Release**

The possible release sources, on-site soil, for the Fina facility are shown in the attached Appendix C and in Tables 1-1 and 1-2. The highest chemical concentrations detected have been selected for review. Tables 2-1, 2-2, and 2-3 provide a summary of the chemicals of potential concern. The depths of detection of chemicals of potential concern for the most recent sampling round are given in Table 2-3. Table 3-1 lists the exposure point concentration for each chemical of potential concern. These values will be used in this risk assessment.

### **3.3.2 Identification of Exposure Points**

#### **Soil**

RAGS identifies an exposure point as any point of potential contact with a contaminated medium (EPA, 1989a). This risk assessment examines hypothetical exposure points. The chemicals at the site were detected at depth. For example, ethylbenzene concentrations used in the risk assessment were detected at 3 to 3.5 feet, benzene at 3 to 3.5 feet, and styrene at 2 to 2.5 feet. Because these chemicals were not found in surface soil, a worker is actually unlikely to come in contact with them during normal activities. It is assumed in this risk assessment that soil chemical concentrations are equivalent to subsurface soil concentrations.

#### **Groundwater**

Chemicals were detected in groundwater at the site; however, the presence of chemicals does not necessarily indicate a risk. No drinking water wells are present on-site. The groundwater, which is shallow in the vicinity of the site, flows into the Little Calumet River, located north of the facility (Figure 3-1). Chemicals were detected in wells located near the river. Based on groundwater flow patterns and the proximity of the wells containing chemicals to the river, it is likely that all the chemicals will eventually discharge to the river.

Because of the depth and proximity of the chemicals to the river, it is also unlikely that the groundwater will be consumed from the site. The facility and the area is connected to the town water supply. Therefore, the consumption of groundwater will not be considered in this risk assessment because it is believed that an exposure point for groundwater does not exist. For the purpose of this risk assessment it is assumed that the Little Calumet River is not a water source since the Calumet City municipal water supply source is Lake Michigan. Though surface water sampling has indicated surface water, i.e., Little Calumet River, has not been impacted by the site, the potential for chemicals to migrate into groundwater from soil does exist.

**TABLE 3-1**

**Exposure Point Concentrations**

<u>Chemical</u>	<u>Highest Concentration (µg/kg)</u>
Benzene	140
Toluene	440
Ethylbenzene	47,000
Styrene	15,000
Phenol	36,000



## **Air**

The chemicals at the site were detected at depth. Therefore, volatilization of VOCs into the air is not considered to be a significant point of release or a significant exposure pathway at the site.

### **3.3.3 Identification of Potential Exposure Pathways**

The next step of the risk assessment process is the identification of routes of exposure for the exposure pathways identified. The following complete, quantifiable PEPs are assumed for the Fina facility risk assessment:

- Inadvertent ingestion; and
- Dermal contact with soil during on-site work activities.

A conservative approach to exposure points (i.e., surface soil), is taken since on-site worker activities will rarely come into contact with soils at the depths where the chemicals were found. Because no on-site groundwater wells exist and all groundwater on-site discharges into the Little Calumet River, exposure to chemicals of concern in groundwater is also considered an unlikely exposure route. As stated earlier it is assumed that the Little Calumet River is not a water source since the Calumet City municipal water supply source is Lake Michigan. The inclusion of exposure to chemicals in air and groundwater may potentially lead to the calculation of a higher risk for the site. An example of air exposure may be an on-site worker performing duties in an excavated trench. Other exposure scenarios could also be constructed; for example, excavation at the site may bring chemicals of potential concern to the surface. However, because the potential for exposure to excavated soils is limited, this exposure scenario was not included in the risk assessment.

### **3.4 Quantification of Exposure**

The third step in the exposure assessment process is to quantify the magnitude, frequency, and duration of potential exposure for the on-site workers and exposure pathways selected for quantitative evaluation.

### **3.4.1 Estimate of Exposure Concentrations**

To provide a conservative estimate of exposure, the maximum chemical concentrations detected on-site for the chemicals of potential concern will be used in this risk assessment.

Using the maximum chemical concentration detected is conservative for a number of reasons. Chemicals of concern were not found in all samples collected at the site. Except for in the former styrene blowdown area, all chemicals except ethylbenzene and formaldehyde were found in two or fewer of the 16 samples collected. Ethylbenzene was found in only 7 of 16 samples. It is reasonable to assume that a worker will have access to all of the site and not just the areas where chemicals were detected. Therefore, it is likely that the majority of a worker's time would be spent in an area that does not contain chemicals. For example, exposure to ethylbenzene in soil may occur, but the average of the exposure concentrations, rather than the maximum detected concentration (i.e., 1,827  $\mu\text{g/kg}$  rather than 47,000  $\mu\text{g/kg}$ ) may be more accurate (but not as conservative), in calculating risk of exposure to ethylbenzene in soil. In the former styrene blowdown area, ethylbenzene and styrene were found at 47,000  $\mu\text{g/kg}$  and 15,000  $\mu\text{g/kg}$ , respectively, in soil below the clean backfill.

### **3.4.2 Estimate of Chemical Intake for On-Site Workers**

To evaluate risk from the exposure point concentrations, an estimated exposure dose is required for each medium. To develop exposure doses, certain assumptions, in combination with exposure point concentrations, must be used. The following section describes the assumptions used in the risk assessment process for each exposure pathway.

#### **3.4.2.1 Inadvertent Ingestion of and Dermal Contact with Soil**

It has been estimated that an adult ingests 10 mg/day of soil (Calabrese et al., 1989). However, this soil ingestion rate will not be used to estimate risk to workers at the Fina site. The value recommended by the U.S. EPA Office of Solid Waste and Emergency Response (Porter, 1989) (100 mg/day of ingested soil), will be used because it is more conservative. It was assumed that only adults (average weight 70 kg) (EPA, 1989a) will have access to the site and that a worker labors at the facility 5 days per week, 48 weeks per year, or 240 of 365 days per year for 45 years of a 75-year lifetime. This corresponds to working at the facility from the age of 20 to the age of 65 and being exposed to chemicals of potential concern at the site every working day.

Both the average lifetime daily dose and the average annual daily dose were calculated for soil ingestion and soil dermal exposure. Average lifetime daily dose was derived for each chemical using an exposure duration of 45 of 75 years to determine risk from chronic exposure. Average

annual daily dose was derived using an exposure duration of 1 year to determine the risk from acute exposure. A conservative gastrointestinal absorption adjustment factor, of 100% (or 1), was used in this risk assessment.

The RAGs equation (EPA, 1989a) for estimating intake of a chemical by inadvertent ingestion of soil is:

$$Intake (mg/kg/day) = \frac{CS \times IR \times CF \times EF \times ED}{BW \times AT}$$

Where: CS = Chemical concentration in soil (mg/kg)  
 IR = Ingestion rate (mg soil/day)  
 CF = Conversion factor (10<sup>-6</sup> kg/mg)  
 EF = Exposure frequency (days/days)  
 ED = Exposure duration (years/years)  
 BW = Body weight (kg)  
 AT = Averaging time (period over which exposure is averaged -- days)

The estimated ingestion exposure doses are shown in Table 3-2.

Absorption adjustment factors are used to evaluate absorption by the body of an inhaled, ingested, or dermally contacted chemical. The chemical may be absorbed onto particulate matter or soil, or suspended or dissolved in water, thereby impacting the absorption. In many cases, the absorption adjustment factors used in the risk assessment will overestimate actual absorption.

For dermal contact, it was assumed that the hands of an adult (990 cm<sup>2</sup>) (EPA, 1989c) are exposed while on-site and that 2.77 mg/cm<sup>2</sup> of soil adhere to skin (EPA, 1989a). This conservative estimate is appropriate for clay. It has been estimated that dermal absorption of benzene ranges from 1% to 0.2% (Franz, 1984). A value of 1% (or .01) for dermal absorption for benzene, ethylbenzene, styrene, and toluene was used in this risk assessment. A dermal absorption adjustment factor of 100% (or 1) was used for phenol.

The U.S. EPA equation for calculating dermal contact with soil (EPA, 1989a) is:

Table 3-2  
Soil Ingestion Exposure  
Worker Scenario

Chemicals	Soil Concentration (ug/kg soil)	Ingestion Rate (mg/day)	Exposure Frequency (Days/Week)	Exposure Duration (Years/Week)	Unit Adjustment Factor (kg/ug)	Gastrointestinal Absorption Adjustment Factor	Body Weight (kg)	Average Lifetime Daily Dose (mg/kg/day)	Average Annual Daily Dose (mg/kg/day)
Benzene	140	100	240/365	45/75	1.00E-09	1	70	7.89E-08	1.32E-07
Ethylbenzene	4700	100	240/365	45/75	1.00E-09	1	70	2.65E-05	4.41E-05
Phenol	34000	100	240/365	45/75	1.00E-09	1	70	2.03E-05	3.38E-05
Styrene	15000	100	240/365	45/75	1.00E-09	1	70	8.45E-06	1.41E-05
Toluene	440	100	240/365	45/75	1.00E-09	1	70	2.48E-07	4.13E-07

Finbenz.wk1, ENSR, 1990.

# Risk from Soil Ingestion Exposure

Chemicals	Average Lifetime Daily Dose (mg/kg/day)	Average Annual Daily Dose (mg/kg/day)	Reference Dose (mg/kg/day)	Worker Hazard Index	Slope Factor (mg/kg/day) <sup>-1</sup>	Excess Lifetime Cancer Risk
Benzene	7.89E-08	1.32E-07	N/A	4.41E-04	2.90E-02	2.29E-09
Ethylbenzene	2.65E-05	4.41E-05	1.00E-01	5.64E-05	(a)	
Phenol	2.03E-05	3.38E-05	6.00E-01	7.05E-05	(a)	
Styrene	8.45E-06	1.41E-05	2.00E-01	1.38E-06	(a)	
Toluene	2.48E-07	4.13E-07	3.00E-01	5.70E-04		
Summed Total	5.56E-05	9.26E-05				2.29E-09

N/A: Not available at this time.

(a): Not carcinogenic by this route of exposure.

Finbenz.wk1, ENSR, 1990.

$$\text{Absorbed Dose (mg/kg/day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Where: CS = Chemical concentration in soil (mg/kg)  
 CF = Conversion factor (10<sup>-6</sup> kg/mg)  
 SA = Skin surface area available for contact (cm<sup>2</sup>/event)  
 AF = Soil-to-skin adherence factor (mg/cm<sup>2</sup>)  
 ABS = Absorption factor (unitless)  
 EF = Exposure frequency (events/year)  
 ED = Exposure duration (years)  
 BW = Body weight (kg)  
 AT = Averaging time (period over which exposure is averaged -- days)

The estimated dermal exposure doses are presented in Table 3-3.

Table 3-3

Soil Dermal Exposure

Worker Scenario

Chemicals	Soil Concentration (mg/kg soil)	Soil Exposed (cm <sup>2</sup> /Day)	Soil on Skin (mg/cm <sup>2</sup> )	Exposure Frequency (Days/Week)	Exposure Duration (Years/Week)	Unit Adjustment Factor (kg/mg)	Dermal Absorption Factor	Body Weight (kg)	Average Lifetime Daily Dose (mg/kg/Day)	Average Annual Daily Dose (mg/kg/Day)
Benzene	140	990	2.77	240/365	45/75	1.00E-09	0.01	70	2.16E-08	3.61E-08
Ethylbenzene	47000	990	2.77	240/365	45/75	1.00E-09	0.01	70	7.26E-06	1.21E-05
Phenol	36000	990	2.77	240/365	45/75	1.00E-09	1	70	5.56E-04	9.27E-04
Styrene	15000	990	2.77	240/365	45/75	1.00E-09	0.01	70	2.32E-06	3.86E-06
Toluene	440	990	2.77	240/365	45/75	1.00E-09	0.01	70	6.80E-08	1.13E-07

Finabenz.uk1, ENSR, 1990.

Risk from Soil Dermal Exposure

Worker Scenario

Chemicals	Average Lifetime Daily Dose (mg/kg/Day)	Average Annual Daily Dose (mg/kg/Day)	Reference Dose (mg/kg/Day)	Worker Hazard Index	Slope Factor (mg/kg/Day)-1	Excess Lifetime Cancer Risk
Benzene	2.16E-08	3.61E-08	N/A	1.21E-04	2.90E-02	6.27E-10
Ethylbenzene	7.26E-06	1.21E-05	1.00E-01	1.55E-03	(a)	
Phenol	5.56E-04	9.27E-04	6.00E-01	1.93E-05	(a)	
Styrene	2.32E-06	3.86E-06	2.00E-01	3.78E-07	(a)	
Toluene	6.80E-08	1.13E-07	3.00E-01	1.69E-03		
Summed Total	5.66E-04	9.43E-04				6.27E-10

N/A: Not available at this time.

(a): Not carcinogenic by this route of exposure.

Finabenz.uk1, ENSR, 1990.

## 4.0 TOXICOLOGICAL PROFILES

### 4.1 Introduction

The objectives of the following toxicity assessment are (1) to weigh available evidence regarding the potential for the chemicals of potential concern at the Fina facility to cause adverse health effects in exposed on-site workers, and (2) to describe the relationship between the dose of a chemical and the increased likelihood and/or severity of adverse effects. The performance of a toxicity assessment generally requires two steps: hazard identification, or characterizing the nature and strength of evidence of causation; and dose-response assessment, in which the toxicity of a chemical is quantitatively evaluated.

The following section provides toxicity profiles and U.S. EPA estimates of the dose-responsiveness of the chemicals of potential concern used for the Fina facility risk assessment. The dose-response evaluation includes assessments for both noncarcinogenic and carcinogenic compounds.

### 4.2 Chemical and Toxicological Properties of Benzene

Benzene is present in automotive fuels and wood and coal distillates, is used primarily as an intermediate for synthetic chemicals and pharmaceuticals. Its physical and chemical properties are listed in Table 4-1.

Benzene is readily absorbed via inhalation and ingestion, but poorly absorbed through intact skin. It is highly lipid soluble, and therefore tends to distribute to fatty tissues (U.S. EPA, 1987). Administration of benzene to rats, dogs, rabbits, and mice via inhalation and/or ingestion results in its rapid uptake and excretion, mainly via exhalation of unchanged benzene (Rickert et al., 1979; Parke and Williams, 1953; Andrews et al., 1977). In humans, the elimination of benzene is biphasic. Approximately 16% is eliminated unchanged via exhalation within 5 hours (Nomiya and Nomiya, 1974a, 1974b). The remaining benzene is stored in fatty tissue and slowly excreted.

#### Human Toxicological Profile

Benzene has been associated with hematologic effects (effects on blood cells) in occupationally-exposed humans. These effects of benzene are hypothesized to be related to actions of metabolites of the compound on the precursors of circulating blood cells that reside in the bone

TABLE 4-1

Chemical/Physical Properties of Benzene

<u>Property</u>	<u>Value</u>
Chemical Formula	$C_6H_6$
Molecular Weight	78.12
Boiling Point	80.1°C
Melting Point	5.56°C
Water Solubility	1,780 mg/L at 25°C
Vapor Pressure	75 mmHg at 20°C
Henry's Law Constant	$5.59 \times 10^{-3} \text{ atm/m}^3/\text{mol}$
$K_{oc}$	$8.30 \times 10^1 \text{ ml/g}$
log octanol/water partition coefficient (log $K_{ow}$ )	1.95-2.13 l/kg
Sources:	Clement, 1985 Public Health Risk Evaluation Database (PHRED), 1988



marrow. Because the toxic effect is difficult to simulate in experimental animals, the mechanism of this action has been difficult to determine. Adverse human effects include anemia (decreased red blood cells), leukopenia (decreased white cells), and thrombocytopenia (decreased platelets). Chronic benzene exposure may lead to pancytopenia (a decrease in all circulating cells) or aplastic anemia (failure to manufacture blood cells altogether) (Goldstein, 1977).

Benzene has been associated with leukemia in workers exposed by inhalation (Aksoy et al., 1974; Infante, 1977a, 1977b; Ott et al., 1978). Benzene is among the few substances given an "A" weight-of-evidence rating by U.S. EPA, indicating there is adequate and sufficient data from human studies to classify the compound as a carcinogen.

Ott et al. (1978) conducted an epidemiologic study to examine long-term mortality in a cohort of 594 workers occupationally exposed to benzene at the Michigan Division of Dow Chemical. This retrospective, cohort-designed study characterized cumulative benzene exposures based on work histories and industrial hygiene records. Fifty-three individuals who experienced concomitant exposure to arsenicals, asbestos, or high vinyl chlorides were treated separately. Observed deaths were much fewer than expected, based on U.S. white male mortality with no statistically significant increases due to any cause-of-death, excluding the 53 individuals mentioned above. Three individual deaths were by either lymphatic cancer or by leukemia, but these conditions could not be directly attributed to benzene exposure.

A five-fold increase in risk of developing leukemia of any type, and a ten-fold excess in deaths attributable to myeloid and monocytic leukemias (two specific types of leukemias) were observed in another retrospective mortality cohort of workers occupationally exposed to benzene (Infante et al., 1977a). Two control populations were used as comparative standards: one was a general U.S. male population, and the other was a non-exposed working male population (N = 1,447). After strong criticism from Tabershaw and Lamm (1977) on the basis of the study's methodology, Infante et al. (1977a) re-analyzed the data using Tabershaw and Lamm's suggested methodology. The re-calculated risk was 8.5-fold versus the original ten-fold risk for excess deaths due to myelogenous and monocytic leukemia.

Although the Infante study was extremely limited in its characterization of exposure, as is often the case in historical perspective epidemiological studies, the authors concluded that a dose-response relationship between benzene exposure and leukemia exists. Additionally, because dermal exposure was not measured, and anecdotal evidence of significant dermal exposure exists (e.g., workers drenched in benzene during some of the operations), the authors may have underestimated benzene exposure and subsequently overestimated the quantitative leukemia risk (Wong, 1985).

## Mammalian Toxicology and Significant Studies

Acute LD<sub>50</sub> values for oral exposure to benzene in rats are age-dependent, and range from 0.87 g/kg to 5.6 g/kg (Kimura, et al., 1970). Dogs and mice exposed to 600 to 1,000 ppm of benzene via inhalation for 12 to 15 days developed leukopenia and fatal anemia respectively (Hough and Freeman, 1944; Petrini, 1941). Rats, guinea pigs, rabbits, and monkeys also developed leukopenia when exposed to benzene (at concentrations of 80 to 85 ppm) via inhalation from 136 to 187 times (Wolf et al., 1956).

Lifetime inhalation exposure to 100 or 300 ppm benzene by rats and mice resulted in lymphocytopenia, anemia, and decreased survival time (Snyder et al., 1980). Later evaluation of the data from Snyder's study showed preliminary evidence of carcinogenicity (U.S. EPA, 1987).

There is no evidence that benzene is teratogenic. However, it has been shown to be a growth inhibitor in utero (U.S. EPA, 1983).

## Regulations and Standards

The current Occupational Safety and Health Administration (OSHA) recommended 10-hour time-weighted average (TWA) level for benzene is 1 ppm. This level corresponds to a daily dose of 16 mg (U.S. EPA, 1987).

Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life from benzene toxicity have not been derived. However, the lowest reported acute toxic level has been seen at 5,300 mg/L.

The following recommended AWQC have been derived for the protection of human health.

<u>Risk Level</u>	<b>EXPOSURE ROUTE</b>	
	<b>Ingesting Organisms and Water (mg/L)</b>	<b>Ingesting Organisms Only (mg/L)</b>
10 <sup>-5</sup>	6.6	400
10 <sup>-6</sup>	0.66	40.00
10 <sup>-7</sup>	0.066	4.0

The U.S. EPA has also promulgated an MCL for benzene of 0.005 mg/L.

The U.S. EPA Carcinogen Assessment Group (CAG) has used the data from three epidemiological studies and, using a linear dose-response model, has obtained an SF of  $2.90 \times 10^{-2} \text{ (mg/kg/day)}^{-1}$  for both oral and inhalation routes of exposure to benzene (U.S. EPA, 1988). A recent study (September 1988) by Clement Associates, Inc., reevaluated the human leukemia risk associated with inhalation exposure to benzene and arrived at a new SF of  $3.48 \times 10^{-3} \text{ (mg/kg/day)}^{-1}$  for inhalation.

### **4.3 Chemical and Toxicological Properties of Ethylbenzene**

Ethylbenzene is an alkyl-substituted aromatic compound widely used in many commercial products and in various petroleum combustion processes. The two major uses of ethylbenzene are in the plastic and rubber industries, where it is used in the synthesis of styrene. At least 50% of the benzene used in the U.S. goes into the production of ethylbenzene. Ethylbenzene is also present in mixed xylenes, which are used as diluents in paints, in agricultural insecticide sprays, and in gasoline blends. Gasolines may contain as much as 20% ethylbenzene. Ethylbenzene has a wide environmental distribution due to its widespread use (U.S. EPA, 1980). Its physical and chemical properties are listed in Table 4-2.

Ethylbenzene has been shown to be readily absorbed via inhalation, ingestion, and dermal exposure (Dutkiewicz and Tyras, 1967; Dutkiewicz and Tyras, 1968; Ivanov, 1962) in humans as well as in laboratory animals. Following inhalation exposure, ethylbenzene is distributed throughout the body, with the highest levels detected in the kidney, lung, adipose tissue, digestive tract, and liver (Chin et al., 1980). There appear to be differences in the metabolism of the chemical in humans and laboratory animals. However, studies of both rats and humans have shown urinary excretion of the chemical to be complete within 24 hours of exposure (El Masry et al., 1956; Engstrom and Bjurstrom, 1978; Hagemann and Angerer, 1979).

### **Human Toxicological Profile**

Little information on the toxicity of ethylbenzene to humans exists in the available literature. Gerarde (1963) reviewed the acute toxicity data in humans following exposure to ethyl benzene via inhalation (U.S. EPA 1980). At levels below 200 ppm, no effects were seen. Concentrations of ethylbenzene from 200 to 1,000 ppm cause eye irritation; at 2,000 ppm, dizziness, lacrimation, and severe eye, nose, and mucous membrane irritation occurs; and at 5,000 ppm, eye, nose, and throat irritation becomes intolerable. No information exists on the effects of chronic, low-level exposure to ethylbenzene in humans.

**TABLE 4-2**
**Chemical/Physical Properties of Ethylbenzene**

<b><u>Property</u></b>	<b><u>Value</u></b>
Molecular Weight	106.2
Boiling Point	136.2°C
Melting Point	-95°C
Water Solubility	161 mg/L at 25°C
Vapor Pressure	7 mmHg at 25°C
Henry's Law Constant	6.44 atm. m <sup>3</sup> /mole
$K_{oc}$	$1.1 \times 10^3$ ml/g
$\log K_{ow}$	3.15 l/kg
Sources: Clement, 1985	
PHRED, 1988	

## Mammalian Toxicology and Significant Studies

Acute toxicity data on ethylbenzene indicate low toxicity of the compound. An oral LD<sub>50</sub> in both male and female rats of 3.5 g/kg has been reported (Wolf, et al. 1956). A four-hour inhalation LD<sub>50</sub> of 4,000 ppm was observed by Smyth, et al. (1962) for female rats. During LD<sub>50</sub> studies, systemic toxic effects were seen predominantly in the liver and kidney (Wolf et al., 1956).

Increased liver and kidney weights were observed in rats orally exposed to 408 to 680 mg/kg/day ethylbenzene (Wolf et al., 1956). No effects were observed in rats exposed to 13.6 and 136 mg/kg/day (U.S. EPA, 1987). No other chronic exposure studies of ethylbenzene were found in the available literature (U.S. EPA, 1980; U.S. EPA, 1987b).

## Regulations and Standards

The U.S. EPA has not classified ethylbenzene as to carcinogenic potential (EPA Group D: not classified), because of the lack of data (U.S. EPA, 1988).

The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended an occupational standard time-weighted average-threshold limit value (TWA-TLV) in air of 100 ppm (ACGIH, 1986).

The U.S. EPA has proposed a Maximum Contaminant Level Goal (MCLG) for ethylbenzene of 0.68 mg/L. Additionally, a U.S. EPA-verified RfD of 0.1 mg/kg/day has been developed for oral exposure. An RfD for chronic inhalation exposure to ethylbenzene is not available at this time (U.S. EPA, 1988).

## 4.4 Chemical and Toxicological Properties of Formaldehyde

Formaldehyde is a colorless, pungent gas that is sold in aqueous solutions containing 30 to 50% formaldehyde and from 0 to 15% methanol. The methanol is added to prevent polymerization. Formaldehyde has many industrial uses as a fungicide, germicide, and in disinfectants and embalming fluids. It is also used in the manufacture of textiles, latex, phenol, urea, thiourea and melamine resins, dyes and inks, and is a component of polymeric foams used to insulate homes. It is used in the paper, photographic and furniture industries, and as an intermediate in drug and pesticide manufacture (Sittig, 1985). The chemical and physical properties of formaldehyde are listed in Table 4-3.

**TABLE 4-3**
**Chemical/Physical Properties of Formaldehyde**

<b><u>Property</u></b>	<b><u>Value</u></b>
Chemical Formula	CH <sub>2</sub> O
Molecular Weight	30.03
Boiling Point	19.5°C
Melting Point	-92°C
Water Solubility	4.00 x 10 <sup>5</sup> mg/L
Vapor Pressure	10.0 mm Hg
Henry's Law Constant	9.87 x 10 <sup>-7</sup> atm-m <sup>3</sup> /mol
K <sub>oc</sub>	3.6 ml/g
log K <sub>ow</sub>	0.00 l/kg
Sources:	Clement, 1985 U.S. EPA, 1986

## **Pharmacokinetics**

Formaldehyde is well absorbed through inhalation, ingestion, and dermal exposure. Formaldehyde is rapidly oxidized to formic acid in various tissues, including the liver and erythrocytes. The elimination half-life was estimated to be 1.5 minutes in monkeys, following intravenous infusion, with blood formic acid levels increasing concomitantly. Much of the formic acid is further oxidized to carbon dioxide and water in laboratory rodents. Urinary excretion of significant amounts of formate salts, and conversion of some formic acid metabolically to labile methyl groups after activation by tetrahydrofolic acid, also occurs (Gosselin et al., 1984).

## **Human Toxicological Profile**

Inadvertent human exposure to formaldehyde occurs predominantly through inhalation and dermal contact. Formaldehyde gas may cause severe irritation of the mucous membranes of the respiratory tract and eyes, while high concentrations may produce edema or spasm of the larynx. Severe obstructive tracheobronchitis may also result from inhalation of high concentrations, while pulmonary edema is uncommon. Exposure of the eyes to aqueous formaldehyde solutions may cause burns. Urticaria has been observed following inhalation of the gas, and repeated exposure may cause dermatitis either from allergy or irritation (Sittig, 1985). Dermal contact causes the skin to become white, hard, rough, and anaesthetic, due to superficial coagulation necrosis. Dermatitis and hypersensitivity frequently result from long-term exposure (Gosselin et al., 1984).

Ingestion of formalin, an aqueous solution of formaldehyde, results in immediate inflammation, ulceration, and/or coagulation necrosis (fixation) of the gastrointestinal mucosa. Corrosive damage is usually not present in the esophagus, but is evident in the stomach and sometimes extends as far as the jejunum. Circulatory collapse and kidney damage may occur shortly after ingestion. Nausea, vomiting, intense abdominal pain, pale clammy skin, vertigo, convulsions, stupor, coma, difficult micturition, and death due to respiratory failure may all result from ingestion of formaldehyde (Gosselin et al, 1984).

Formaldehyde probably reacts with the mucosa of the alimentary and respiratory tracts. In vitro and in vivo, it has been shown to react with a variety of functional groups resulting in the formation of addition products or the initiation of polymerization reactions. Sulfhydryl reagents antagonize the lethal effects of injected formaldehyde in rodents (Gosselin et al., 1984).

## **Mammalian Toxicology and Significant Studies**

Formaldehyde has been observed to be carcinogenic in rats following inhalation of vapors for 30 hours per week, for up to 24 months at concentrations of 2, 6, and 15 ppm. Formaldehyde failed to produce tumors in mice that were similarly exposed. Reportedly, three rats developed nasal cavity squamous cell carcinomas after 12 months of exposure to 15 ppm formaldehyde. A total of 95 nasal cavity carcinomas had been reported by the end of the 24-month exposure at the 15 ppm level and some deaths occurred. It is unclear whether the lower-dose groups developed any tumors or not (ACGIH, 1986). The ACGIH has categorized formaldehyde as an A2 carcinogen, which means that it has suspected carcinogenic potential for man. The EPA has not categorized formaldehyde as a carcinogen.

Formaldehyde has been reported to produce death in laboratory animals following exposures of 10 hours at concentrations of about 15 ppm. Concentrations of 700 ppm were fatal to cats after 8 hours of exposure, and to mice after 2 hours. An  $LC_{50}$  of 81 ppm for rats has been reported, although the length of exposure was not stated. Mice and rabbits died after inhalation of a 15 to 16 ppm aerosol of formaldehyde. Increased airway resistance in guinea pigs was reported following inhalation of a 0.31 ppm aerosol (ACGIH, 1986).

### **Regulations and Standards**

Health-based criteria for oral exposure to formaldehyde, such as an RfD, or an SF have not been established. An SF of  $4.5 \times 10^{-2} \text{ (mg/kg/day)}^{-1}$  has been established for the inhalation route of exposure (U.S. EPA, 1989). Formaldehyde is classified as a B1 carcinogen through inhalation and oral routes of exposure (U.S. EPA, 1989). The ACGIH (1986) has established a TWA-TLV of 1 ppm ( $1.5 \text{ mg/m}^3$ ). The NIOSH recommended exposure limit is 0.1 ppm as a 15-minute ceiling limit (ACGIH, 1986).

### **4.5 Chemical and Toxicological Properties of Styrene**

Styrene monomer is a colorless, oily liquid with an aromatic odor. It is widely used in making polystyrene plastics, protective coatings, styrenated polyesters, copolymer resins, and as a chemical intermediate (ACGIH, 1986). The chemical and physical properties of styrene are listed in Table 4-4.

Information on the toxic effects of styrene to humans has been derived from controlled experiments using human volunteers and from studies of occupational exposure. Styrene administered by inhalation at high doses results in central nervous system (CNS) effects such as drowsiness, listlessness, and an altered sense of balance (800 ppm exposure, 4 hours) (Carpenter et al., 1944). Gambarele and Hultengren (1974) reported a dose-related increase in reaction time following exposure to 50, 150, 250, and 350 ppm styrene.



**TABLE 4-4**

**Chemical/Physical Properties of Styrene**

<b><u>Property</u></b>	<b><u>Value</u></b>
Molecular Weight	104.14
Specific Gravity	0.9059 at 20°C
Melting Point	-30.6°C
Boiling Point	145.2°C
Vapor Pressure	4.3 torr at 15°C

Source: ACGIH, 1986

Steward and co-workers exposed nine human volunteers to styrene vapor at concentrations of 50, 100, 216, and 376 ppm for varying periods up to 7 hours. None of the volunteers exposed at 50 ppm for 1 hour experienced any subjective symptoms. Vapor exposure at 100 ppm produced mild but transient subjective responses in half of those exposed. Unpleasant subjective symptoms and definite subjective signs of neurologic impairment were experienced by a majority of the individuals at 376 ppm (ACGIH, 1986).

Styrene has been shown to cause changes in hepatic enzyme activity following both acute and chronic oral exposure in rats (Das et al., 1981; Srivastava et al., 1982).

Reproductive effects of styrene have also been investigated in laboratory animals. Teratological evaluations of styrene administered via inhalation have also been performed on mice, hamsters, rats, and rabbits. Most of these studies report negative teratological results (Murray et al., 1978 a, 1978b; Kankaanpaa et al., 1980). However, Kankaanpaa, et al. (1980) reports significant increases in dead or resorbed fetuses.

### **Regulations and Standards**

The OSHA standards for styrene are 100 ppm (8-hour TWA), 200 ppm (ceiling), and a maximum peak concentration of 600 ppm for 5 minutes or less in any 3-hour period. The ACGIH has established a TWA-TLV of 50 ppm and a short-term exposure limit (STEL) of 100 ppm. NIOSH recommends a styrene workplace concentration limit of 50 ppm (TWA for up to a 10-hour day, 40-hour work week) and a ceiling concentration of 100 ppm (NIOSH, 1985).

The U.S. EPA has set an RfD for ingestion of styrene at  $2 \times 10^{-1}$  mg/kg/day and proposed a MCLG for styrene under the Safe Drinking Water Act of 0.14 mg/L (U.S. EPA, 1988).

### **4.6 Chemical and Toxicological Properties of Toluene**

Toluene is an aromatic hydrocarbon that is both volatile and flammable. It is produced largely from petroleum or petrochemical processes and, on a small scale, from metallurgical coke manufacturing. Approximately 70% of the toluene produced is converted to benzene; 15% is used in manufacturing benzoic acid, benzaldehyde, explosives, dyes, and other compounds. The remainder is used as a gasoline derivative and as a solvent for paints, lacquers, gums, and resins. Chemical and physical properties of toluene are listed in Table 4-5.

**TABLE 4-5**

**Chemical/Physical Properties of Toluene**

<b><u>Property</u></b>	<b><u>Value</u></b>
Chemical Formula	$C_6H_5CH_3$
Molecular Weight	92.13
Boiling Point	110.6°C
Melting Point	-95°C
Water Solubility (mg/L)	534.8
Vapor Pressure	28.1 mmHg at 25°C
$K_{oc}$	$3.00 \times 10^2$ ml/g
$\log K_{ow}$	2.69 l/kg
Source: Clement, 1985	

---

## **Fate and Transport**

Toluene has a vapor pressure of 28.1 mmHg at 25°C (Mackay et al., 1982) and a log octanol/water partition coefficient (log  $K_{ow}$ ) of 2.69 (Tute, 1971). It is therefore only slightly soluble in water. The transport and persistence of toluene under environmental conditions is not well known, but it has been shown to be readily transferred from water surfaces to the atmosphere (Mackay and Nolkoff, 1973).

The half-life of toluene in air is 1.3 days, based on its reaction with hydroxyl radicals. However, in the presence of smog, this half-life may be shorter because of the reaction of toluene with  $\text{NO}_x$  (Van Aalst et al., 1980). The half-life is 14.1 in water. Although information regarding the soil half-life of toluene could not be located in the literature, evaporation is thought to be the most

important mechanism of loss from surface soil. In subsurface soil, toluene may undergo varying degrees of biodegradation, depending on the nature of the soil. Underground toluene may percolate through soil into groundwater (Wilson et al., 1981).

## **Pharmacokinetics**

Toluene is primarily absorbed through the lung and intestine. Human studies have also shown rapid adsorption through the respiratory tract (Astrand et al., 1972). Gastrointestinal adsorption information, limited to animal studies, indicates that absorption is relatively rapid (Pyykko et al., 1977). While toluene is a relatively common water contaminant, available studies have not indicated that it is highly toxic. It can also be absorbed through the skin, though to a considerably lesser degree. The compound is rapidly taken up from the bloodstream and distributed to the various body tissues according to their lipid content. Toluene is metabolized extensively and excreted in the urine as well as in expired air.

## **Human Toxicological Profile**

The primary hazard associated with exposure to toluene is CNS depression. Depending on the concentration, and its absorption route, effects range from exhilaration and light-headedness to dizziness and unconsciousness. Inhalation of low concentrations may be irritating to mucous membranes and produce a decrement in psychophysiological functions.

Although long-term exposure to toluene is common, there are few reports to suggest that it has produced adverse effects. One study by Greenburg et al. (1942) indicates an increased incidence of hepatomegaly in painters exposed from 2 weeks to 5 years to solvent mixtures in which toluene was the major component. On the other hand, a low incidence of hepatorenal

insult has been noted among "glue-sniffers," those that purposely inhale toluene to inebriate themselves (Massengale et al., 1963; Barman et al., 1964). However, residual CNS damage has been noted in those intentional abusers. These findings should be cautiously interpreted, because the products are often complex mixtures of different compounds.

### **Mammalian Toxicology and Significant Studies**

Several animal studies have shown that toluene can significantly influence the biological fate and bioeffects of other agents. Prolonged pre-exposure to toluene may enhance the metabolism of a second compound. If given concurrently with other agents, it may inhibit the metabolism of itself and the other agents (Ikeda, 1974). Both cases could be detrimental, depending on whether the parent compound or the metabolites are the toxic agents.

There have been no accounts of teratogenic effects in humans from toluene exposure. Most animal studies have also shown that toluene is not teratogenic, although Nawrot and Staples (1979) observed a significant increase in embryonic death of mice. Maternal toxicity was not seen after exposure to toluene at any dose level. Hudak and Ungvary (1978) observed some skeletal abnormalities at all three maternal inhalation dose levels (1,000 mg/m<sup>3</sup> for 8 hours/day; 1,500 mg/m<sup>3</sup> continuously at 2 different gestational periods).

### **Regulations and Standards**

Existing guidelines for toluene include OSHA's standard of 200 ppm for a 8-hour TWA concentration, with an acceptable ceiling of 300 ppm (Centers for Disease Control, 1986). NIOSH has recommended an exposure limit of 100 ppm as an 8-hour TWA with a ceiling of 200 ppm for 10 minutes (Centers for Disease Control, 1986). This was recommended because of the subjective and objective signs of mucous membrane irritation and the depression effects on the CNS upon acute inhalation exposure of humans to 200 ppm toluene.

The AWQC for drinking water is 14.3 mg/L. The level, if consumed through fish and shellfish, is 424 mg/L (U.S. EPA, 1988).

The oral RfD value is 0.30 mg/kg/day or 21 mg/day for a 70-kilogram human. This dose is also based on the chronic inhalation data described above (Chemical Industrial Institute of Toxicology [CIIT], 1980). Route-to-route extrapolation (U.S. EPA, 1988) was performed; continuous exposure on assumed daily respiratory volume for humans (20 m<sup>3</sup> of air), and a 50% absorption factor (i.e. 50% of the substance ingested would be absorbed) were all factored in to derive the RfD. An RfD for chronic inhalation exposure does not exist at this time (U.S. EPA, 1988). The U.S. EPA has not classified toluene with respect to its carcinogenic potential; it therefore has a ranking on the CAG's weight-of-evidence scale of "D".

## 5.0 RISK CHARACTERIZATION

During the final step of the baseline health risk assessment, the risk characterization, the dose-response information is integrated with estimates of human exposure derived during the exposure assessment. The result is a qualitative and quantitative estimate of the likelihood that humans may experience any adverse health effects, given the exposure assumptions made. Two general types of health risks are characterized for each potential exposure pathway (PEP) considered: potential carcinogenic risks and potential noncarcinogenic risks. A general description of the risk characterization process is presented below.

### 5.1 Risk Characterization Process

#### 5.1.1 Carcinogenic Effects

Carcinogenic risk characterization involves the estimate of 95% upper bound probability that cancer will occur in the potentially exposed population. The SF for a given chemical is multiplied by the lifetime average daily dose to estimate incremental lifetime cancer risk. This is the likelihood, over and above the background cancer rate, that an exposed individual will contract cancer in his or her lifetime. The risk value is expressed as a probability (e.g.,  $1 \times 10^{-6}$  or one in one million). The total incremental lifetime cancer risk is calculated for each PEP by summing the risk for each individual compound.

$$\text{Lifetime Incremental Cancer Risk} = \text{Average Lifetime Daily Dose (mg/kg/day)} \times \text{Slope Factor (mg/kg/day)}^{-1}$$

The U.S. EPA uses an acceptable risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  (NCP, 1989). This risk range is also the basis for the design of remedial alternatives at Superfund sites (EPA, 1990).

#### 5.1.2 Noncarcinogenic Effects

Noncarcinogenic risk characterization is performed by comparing the estimated average annual daily dose of a compound for a given exposure pathway (as derived in the exposure assessment) with the RfD (described in the toxicity assessment section). The average annual daily dose is the dose received during 1 year of on-site exposure. For each compound in each exposure pathway, the average annual daily dose is divided by the RfD in order to determine the Hazard Index (HI). When the HI is less than one, the RfD has not been exceeded, and no

adverse noncarcinogenic health effects are expected. If the HI is greater than one, there may be a potential for adverse noncarcinogenic health effects<sup>1</sup>. A total HI is calculated for each PEP by summing the HIs for each individual compound.

$$\text{Hazard Index} = \frac{\text{Dose on Day of Exposure (mg/kg/day)}}{\text{RfD (mg/kg/day)}}$$

The final step in the risk characterization procedure is to calculate the total potential health risk for a given receptor. This calculation is the sum of all potential risks from each exposure pathway with which a given receptor is involved. For carcinogens, the estimated incremental lifetime cancer risks for all exposure pathways are summed to predict the total potential carcinogenic risk to an individual. A similar approach is taken for noncarcinogens by summing the HIs.

Potential human health risk values are presented for the soil exposure pathway in the following sections.

## 5.2 Potential On-Site Worker Health Risk from Soil Exposure

Potential carcinogenic effects and noncarcinogenic effects to a potentially exposed on-site worker associated with inadvertent ingestion of and dermal contact with impacted on-site soil are presented in Tables 3-2 and 3-3.

### 5.2.1 Carcinogenic Effects

The lifetime incremental cancer risk for soil ingestion is  $2.29 \times 10^{-9}$ , or approximately two in one billion. The lifetime incremental cancer risk for dermal exposure to soil is  $6.27 \times 10^{-10}$ , or approximately six in ten billion. The sum of these two risks,  $2.9 \times 10^{-9}$ , or approximately three in one billion, is the total excess lifetime cancer risk for the soil exposure scenario assumed in this risk assessment. This risk, of three in one billion, is considered acceptable based on the

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<sup>1</sup>The procedure described is used as a screening tool for evaluating potential adverse noncarcinogenic health effects. An HI that exceeds one does not mean that adverse effects will definitely occur. It indicates only that the potential exists and that further evaluation is appropriate. The RfD derived for each chemical is based upon chemical-specific toxic endpoints. The endpoint for each of the indicator chemicals therefore varies. If the total HI exceeds one, further evaluation is necessary to reexamine organ specific toxicity to address those specific chemicals with higher concentrations.



U.S. EPA acceptable risk range of  $10^{-4}$  to  $10^{-6}$ , and therefore, does not pose a human health cancer risk in this soil exposure scenario.

### **5.2.2 Noncarcinogenic Effects**

The HI ( $5.7 \times 10^{-4}$ ) for the soil ingestion exposure pathway does not exceed one, which indicates that adverse noncarcinogenic health effects are not expected to occur via the soil ingestion exposure pathway. The HI ( $1.69 \times 10^{-3}$ ) for the soil dermal exposure pathway does not exceed one. The sum of these two HIs ( $2.26 \times 10^{-3}$ ) also does not exceed one, indicating that adverse noncarcinogenic health effects are not expected to occur via soil exposure.

### **5.3 Summary**

The purpose of this risk assessment is to provide an estimate of the magnitude of potential health risks associated the City, Illinois Fina site. This risk assessment examined soil for benzene, toluene, ethylbenzene, phenol and styrene for an on-site worker exposure. Based on the worker exposure scenario utilized, the present risk levels on-site are acceptable. However, the potential for migration to groundwater presently exists and the inclusion of additional pathways may elevate risk.

It must be stressed that the risks presented in this risk assessment are not absolute risks, but are mathematical estimations based on a number of assumptions. Associated with these assumptions are a number of uncertainties, many of which are conservative in matter and designed to protect human health.

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**APPENDIX A**

**1ST ROUND SAMPLING  
JUNE, 1989**



TABLE 2-1

RESULTS OF SOIL SAMPLING AT FINA/CODSEN CHEMICAL

Second Sampling

Chemical of Interest	Sample Point #1	Sample Point #2	Sample Point #3	Sample Point #4	Sample Point #5	Sample Point #6
Benzene	BDL <sup>1</sup>	BDL	BDL	BDL	BDL	BDL
Toluene	BDL <sup>2</sup>	BDL	(100) ppb <sup>3</sup>	BDL	BDL	BDL
Ethylbenzene	3,600 ppb	47,000 ppb	10,000 ppb	1,200 ppb	2,000 ppb	(350) ppb
Xylene	BDL	BDL	680 ppb	360 ppb	BDL	BDL
Styrene	BDL	BDL	3,100 ppb	BDL	1,400 ppb	15,000 ppb

<sup>1</sup>BDL: Below Detection Limit. Benzene detection limit is 5 ug/kg (ppb).

<sup>2</sup>BDL: Below Detection Limit. Toluene detection limit is 5 ug/kg (ppb).

<sup>3</sup>ppb = ug/kg of soil.

# C E R T I F I C A T E   O F   A N A L Y S I S

## CORRESPOND TO

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

## SAMPLE

EMS SAMPLE : C6591  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/04/89

## REPORT TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## BILL TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## DESCRIPTION

COSDEN CHEMICAL  
BP1-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 14:30:00

TEST DESCRIPTION ANALYTE	RESULT	METHOD	DATE DET. LIMIT	ANALYST UNITS
VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..SW846-8240			07/01/89	SHG
GC/MS File .....	: CV3670		NA	
Date/Time of Analysis.....	: 7/1/89			
Continuing Calibration File ..	: CV3668.C			
Method Blank File .....	: CV3669.B			
MS/MSD File .....	: CV3676.M			
SURROGATE LIST (spike conc)	:			
Dichloroethane-d4.....	: 96		(2500)	% Rec
Toluene-d8.....	: 96		(2500)	% Rec
Bromofluorobenzene.....	: 99		(2500)	% Rec
TARGET COMPOUND LIST	:			
Benzene.....	: BDL		250	uG/KG
Ethylbenzene.....	: 3600		250	uG/KG
Styrene.....	: BDL		250	uG/KG
Toluene.....	: BDL		250	uG/KG
Xylenes (total).....	: BDL		250	uG/KG

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine Sankar

Page 1 of 1

# C E R T I F I C A T E   O F   A N A L Y S I S

## CORRESPOND TO

## SAMPLE

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

EMS SAMPLE : C6592  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/04/89

## REPORT TO

## BILL TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## DESCRIPTION

COSDEN CHEMICAL  
BP2-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 14:35:00

TEST DESCRIPTION ANALYTE	RESULT	METHOD	DATE DET. LIMIT	ANALYST UNITS
VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..SW846-8240			07/01/89	SHG
GC/MS File .....	CV3671		NA	
Date/Time of Analysis.....	7/1/89			
Continuing Calibration File ..	CV3668.C			
Method Blank File .....	CV3669.B			
MS/MSD File .....	CV3676.M			
SURROGATE LIST (spike conc) :				
Dichloroethane-d4.....	93		(5000)	% Rec
Toluene-d8.....	100		(5000)	% Rec
Bromofluorobenzene.....	96		(5000)	% Rec
TARGET COMPOUND LIST :				
Benzene.....	BDL		500.	uG/KG
Ethylbenzene.....	47,000		500.	uG/KG
Styrene.....	BDL		500.	uG/KG
Toluene.....	BDL		500.	uG/KG
Xylenes (total).....	BDL		500.	uG/KG

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine Sankar

Page 1 of 1

# C E R T I F I C A T E   O F   A N A L Y S I S

**CORRESPOND TO**

**SAMPLE**

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

EMS SAMPLE : C6593  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/03/89

**REPORT TO**

**BILL TO**

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## D E S C R I P T I O N

COSDEN CHEMICAL  
BP3-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 14:40:00

**TEST DESCRIPTION**  
**ANALYTE**

**RESULT**

**METHOD**

**DATE**  
**DET. LIMIT**

**ANALYST**  
**UNITS**

VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..SW846-8240

06/30/89  
NA

SHG

GC/MS File ..... : CV3665  
Date/Time of Analysis..... : 6/30/89  
Continuing Calibration File .. : CV3656.C  
Method Blank File ..... : CV3662.B  
MS/MSD File ..... : CV3676.M

SURROGATE LIST (spike conc) :

Dichloroethane-d4..... : 88 (2500) % Rec  
Toluene-d8..... : 106 (2500) % Rec  
Bromofluorobenzene..... : 89 (2500) % Rec

TARGET COMPOUND LIST :

Benzene..... : BDL 250. uG/KG  
Styrene..... : 3100 250. uG/KG  
Toluene..... : (100) 250. uG/KG  
Xylenes (total)..... : 680 250. uG/KG  
Ethyl Benzene..... : 10,000 250. uG/KG

( ) - Estimated Concentration.

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine S. Kao

Page 1 of 1

# C E R T I F I C A T E   O F   A N A L Y S I S

## CORRESPOND TO

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

## SAMPLE

EMS SAMPLE : C6594  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/04/89

## REPORT TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## BILL TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## DESCRIPTION

CODSEN CHEMICAL  
BP4-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 14:45:00

TEST DESCRIPTION ANALYTE	RESULT	METHOD	DATE DET. LIMIT	ANALYST UNITS
VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..SW846-8240			07/01/89	SHG
GC/MS File .....	CV3672		NA	
Date/Time of Analysis.....	7/1/89			
Continuing Calibration File ..	CV3668.C			
Method Blank File .....	CV3669.B			
MS/MSD File .....	CV3676.M			
SURROGATE LIST (spike conc)	:			
Dichloroethane-d4.....	96		(2500)	% Rec
Toluene-d8.....	96		(2500)	% Rec
Bromofluorobenzene.....	100		(2500)	% Rec
TARGET COMPOUND LIST	:			
Benzene.....	BDL		250	uG/KG
Ethylbenzene.....	1200		250.	uG/KG
Styrene.....	BDL		250.	uG/KG
Toluene.....	BDL		250.	uG/KG
Xylenes (total).....	360		250.	uG/KG

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine Salka

# C E R T I F I C A T E   O F   A N A L Y S I S

## CORRESPOND TO

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

## SAMPLE

EMS SAMPLE : C6595  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/04/89

## REPORT TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## BILL TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## DESCRIPTION

COSDEN CHEMICAL  
BP5-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 14:50:00

TEST DESCRIPTION ANALYTE	RESULT	METHOD	DATE DET. LIMIT	ANALYST UNITS
VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..	SW846-8240		07/01/89	SHG
GC/MS File .....	CV3673		NA	
Date/Time of Analysis.....	7/1/89			
Continuing Calibration File ..	CV3668.C			
Method Blank File .....	CV3669.B			
MS/MSD File .....	CV3676.M			
SURROGATE LIST (spike conc)	:			
Dichloroethane-d4.....	98		(10,000)	% Rec
Toluene-d8.....	98		(10,000)	% Rec
Bromofluorobenzene.....	104		(10,000)	% Rec
TARGET COMPOUND LIST	:			
Benzene.....	BDL		1000.	uG/KG
Ethylbenzene.....	2000		1000.	uG/KG
Styrene.....	1400		1000.	uG/KG
Toluene.....	BDL		1000.	uG/KG
Xylenes (total).....	BDL		1000.	uG/KG

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine Sarker

Page 1 of 1

# C E R T I F I C A T E   O F   A N A L Y S I S

**CORRESPOND TO**

**SAMPLE**

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

EMS SAMPLE : C6596  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/04/89

**REPORT TO**

**BILL TO**

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## D E S C R I P T I O N

COSDEN CHEMICAL  
BP6-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 14:55:00

TEST DESCRIPTION ANALYTE	RESULT	METHOD	DATE DET. LIMIT	ANALYST UNITS
VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..SW846-8240			07/01/89	SHG
GC/MS File .....	CV3674		NA	
Date/Time of Analysis.....	7/1/89			
Continuing Calibration File ..	CV3668.C			
Method Blank File .....	CV3669.B			
MS/MSD File .....	CV3676.M			
SURROGATE LIST (spike conc)	:			
Dichloroethane-d4.....	97		(5000)	% Rec
Toluene-d8.....	98		(5000)	% Rec
Bromofluorobenzene.....	102		(5000)	% Rec
TARGET COMPOUND LIST	:			
Benzene.....	BDL		500.	uG/KG
Ethylbenzene.....	(350)		500.	uG/KG
Styrene.....	15,000		500.	uG/KG
Toluene.....	BDL		500.	uG/KG
Xylenes (total).....	BDL		500.	uG/KG
( ) - Estimated Concentration				

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine Sanka

Page 1 of 1



# C E R T I F I C A T E   O F   A N A L Y S I S

## CORRESPOND TO

EMS Laboratories, Inc  
8205 S. Cass Ave. Suite 106  
Darien, Illinois 60559  
(312) 969-9030

## SAMPLE

EMS SAMPLE : C6597  
REPORT DATE : 07/05/89  
DATE RECEIVED : 06/23/89  
DATE COMPLETE : 07/04/89

## REPORT TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## BILL TO

ENSR CONSTRUCTORS  
740 PASQUINELLI DRIVE  
WESTMONT IL 60559

## DESCRIPTION

CODSEN CHEMICAL  
BP7-02  
P.O. NUMBER : 72483

DATE : 06/23/89  
TIME : 15:00:00

TEST DESCRIPTION ANALYTE	RESULT	METHOD	DATE DET. LIMIT	ANALYST UNITS
VOLATILE ORGANICS, RCRA (HEATED PURGE AND TRAP) ..SW846-8240			07/01/89	SHG
GC/MS File .....	CV3675		NA	
Date/Time of Analysis.....	7/1/89			
Continuing Calibration File ..	CV3668.C			
Method Blank File .....	CV3669.B			
MS/MSD File .....	CV3676.M			
SURROGATE LIST (spike conc)				
Dichloroethane-d4.....	98		(250,000)	% Rec
Toluene-d8.....	94		(250,000)	% Rec
Bromofluorobenzene.....	101		(250,000)	% Rec
TARGET COMPOUND LIST				
Benzene.....	BDL		25000.	uG/KG
Ethylbenzene.....	150,000		25000.	uG/KG
Styrene.....	110,000		25000.	uG/KG
Toluene.....	BDL		25000.	uG/KG
Xylenes (total).....	BDL		25000.	uG/KG

ND - Not Detected

NA - Not Applicable

BDL - Below Detection Limit

Sample was accompanied by chain of custody papers

Approved by : Christine Sankar

Page 1 of 1

ROAD

BLOWDOWN  
PIT

EXCAVATE  
27' 10" NN

⑥  
12' EW  
130' NS

⑦

←  
1' NS  
125' EW  
BUILDING

18' FT  
⑤ 9' NS  
115' EW

←  
9' NS  
④ 70' EW  
↑

58' FT

22' FT

⑧ MW

118' FT

60' FT

③  
40' EW, 2' NS  
→ ↑

9' NS

②  
55' EW

↖

① ∇ 7' FT  
15' NS, 10' FT EW  
↑ ↖

40' FT

↖  
N

SAMPLE LOCATIONS ROUND 2

**APPENDIX B**  
**2ND ROUND SAMPLING**  
**FEBRUARY, 1990**

**Fina Oil and Chemical  
Cosden Chemical Division**

**Calumet City, Illinois**

**Results of Phenol Sampling  
at Several Plant Locations**

**ENSR Constructors**

**March 1990**

**Project Number 225005**

# ENSR

## ENSR Constructors

740 Pasquinelli Drive  
Suite 124  
Westmont, Illinois 60559  
708-887-1700

March 16, 1990

Mr. Gerry Hardin  
Fina Oil & Chemical Company  
Cosden Chemical Division  
P.O. Box 178  
Calumet City, IL 60409

Dear Gerry:

Enclosed are the results of the sampling activities which took place on February 21, 1990. This sampling was done in connection with the phenol concern.

If we may be of any further help to you in regards to this, or any other matter, please do not hesitate to call.

Sincerely,

ENSR CONSTRUCTORS



James Barbato  
General Manager  
Midwest Region

## TABLE OF CONTENTS

INTRO

Appendix A

Site Sample Locations

Appendix B

Chain of Custody Form

Appendix C

Condensed Analytical Results

Appendix D

Complete Analytical Results



Formerly ERT

March 16, 1990

ENSR Consulting  
and Engineering  
740 Pasquinelli Drive  
Westmont, Illinois 60559  
(708) 887-1700  
FAX (708) 850-5307

Mr. Gerry Hardin  
Fina Oil & Cosden Chemical  
Cosden Chemical Division  
P.O. Box 178  
Calumet City, Illinois 60409

SUBJECT: Collection of Soil Samples at the Fina Oil, Cosden  
Chemical Facility in Calumet City, Illinois

Dear Mr. Hardin:

As you requested, on February 21, 1990, soil samples were collected at the 10 locations depicted on the Figure in Appendix A. The soil samples were collected adjacent to 4 on-site manholes and 6 manholes running along the west side of Paxton Avenue. The soil samples were collected at the various locations from the ground surface to a depth of 6-inches below ground surface.

Mr. Tom Adkins, of Gabriel Environmental, collected split samples to be analyzed at the Gabriel Laboratory. As understood by ENSR, Mr. Adkins was providing consulting services for Ashland Chemical. All samples were collected using a decontaminated hand spade. The decontamination procedure consisted of an Alconox™ soap and potable water wash followed by a potable water rinse. The spade was then rinsed with methanol and allowed to air dry.

The 10 soil samples were delivered in an iced cooler to the Heritage (EMS) laboratory in Darien, Illinois. The samples were analyzed for acid and base/neutral extractables and purgeable organics. The samples were delivered under Chain of Custody Procedures (see Appendix B). The laboratory results are attached (see Appendix C & D).

# ENSR

Mr. Gerry Hardin  
March 19, 1990  
Page 2

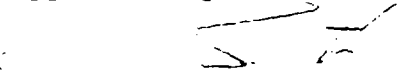
ENSR appreciates the opportunity to be of service to Fina Oil & Cosden Chemical. If you have any questions, please do not hesitate to call.

Sincerely,



Scott F. Symonds  
Senior Staff Engineer

Approved by:



Gregory J. Smith  
Department Manager  
Senior Hydrogeologist

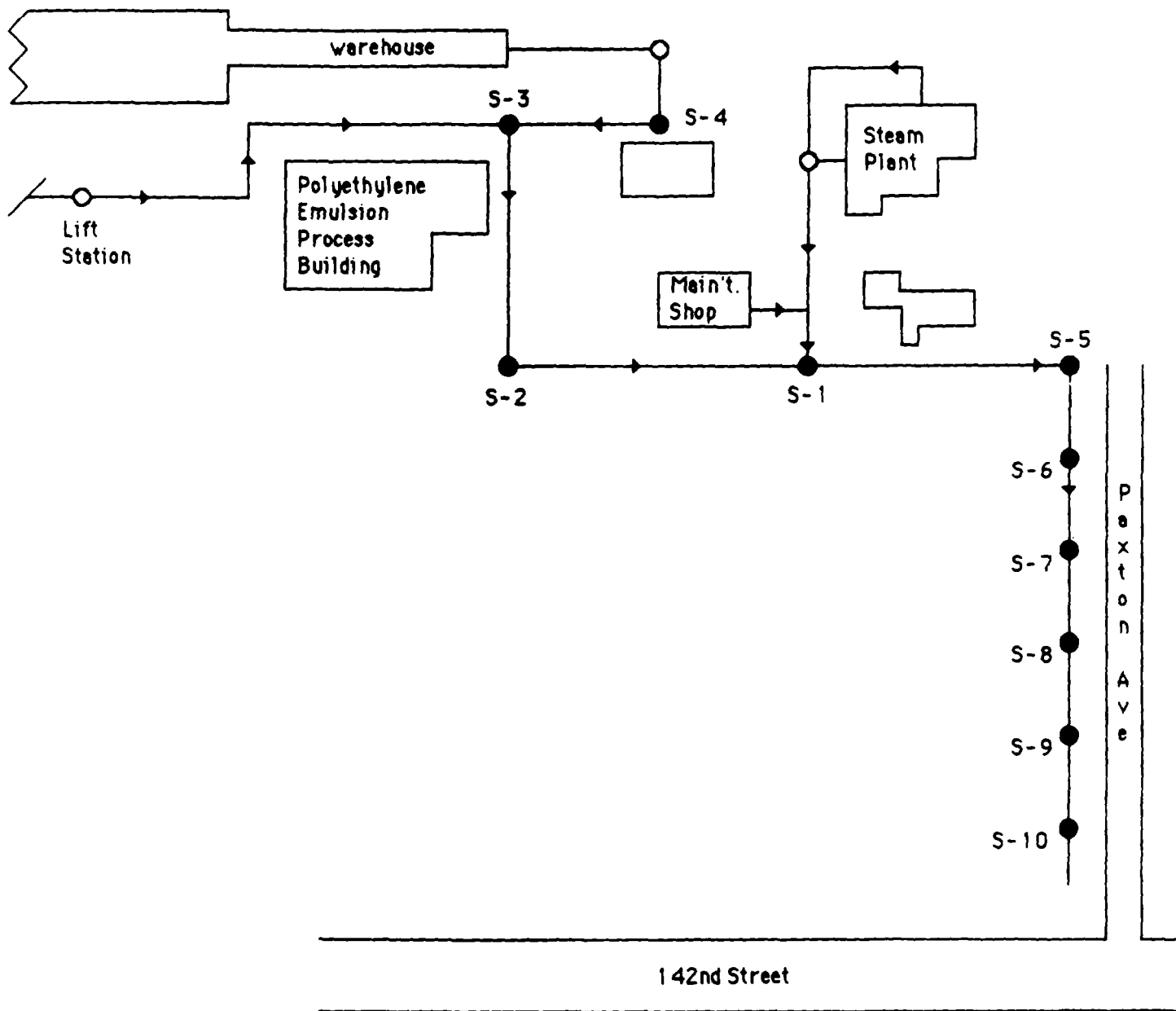
SFS/GJS/js

Enclosure

ENSR Program No. 9500-058-260  
Ref. No. 90-03-G247



Appendix A  
Site Sample Locations



Plot Plan  
Sanitary Sewer  
and  
Sample Locations  
Fine Oil and Chemical Company  
Columet City, Illinois

Appendix B  
Chain of Custody Form

# ENSR

**CONSULTING AND ENGINEERING**  
2025 RICHMOND AVENUE HOUSTON, TX 77006 (713) 526-1465

**Analysis Request and Chain of Custody Record**

Project no. 225-005-001		Client/Project Name Fina Oil Chemical			Project Location Calumet City	
Lab ID No	Field Sample No./ Identification	Date and Time	Sample Container (Size/Label)	Sample Type (Liquid, Sludge, Etc.)	Preservative	ANALYSIS REQUESTED
	S-1	2-21 1000	1 liter NAB	Soil	4%	Heavy Metals, PCBs, PAHs, and Pesticides
	S-2	2-21 1010	"	Soil	"	"
	S-3	2-21 1020	"	Soil	"	"
	S-4	2-21 1030	"	Soil	"	"
	S-5	2-21 1040	"	Soil	"	"
	S-6	2-21 1045	"	Soil	"	"
	S-7	2-21 11	"	Soil	"	"
	S-8	2-21 115	"	Soil	"	"
	S-9	2-21 1125	"	Soil	"	"
	S-10	2-21 1150	"	Soil	"	"
Samplers: (Signature)		Relinquished by: A. H. 1. Hymowitz		Date: 2-21	Received by: (Signature)	Date: 2-21
Affiliation: GCHH Systems		Relinquished by: (Signature)		Date: 2-21	Received by: (Signature)	Date: 2-21
Relinquished by: (Signature)		Relinquished by: (Signature)		Date: 2-21	Received by: (Signature)	Date: 2-21
REMARKS:		1. Two Perbuto 100g samples				
		2				

Appendix C  
Condensed Analytical  
Results

Fina Oil and Chemical / Cosden Chemical Division  
 Phenol Sampling Program Results  
 Samples Taken February 21, 1990

	Sample S-1	Sample S-2	Sample S-3	Sample S-4
Acetone	490 ppb	1800 ppb	170 ppb	190 ppb
Ethylbenzene	9	BDL	BDL	BDL
Fluorotrichloromethane	3*	3*	4*	4*
2-Hexanone	6	BDL	BDL	BDL
Methylene Chloride	BDL	35	BDL	BDL
Methyl Ethyl Ketone	9*	12	BDL	BDL
4-Methyl-2-Pentanone	BDL	10*	BDL	BDL
Styrene	110	72	BDL	BDL
Tetrachloroethene	BDL	BDL	BDL	BDL
Toluene	40	85	10	21
Xylenes (total)	12	21	6	9
Ethyl Methyl Benzene	72	178	BDL	BDL
Anthracene	BDL	BDL	BDL	BDL
Bis(2-ethylhexyl)Phthalate	BDL	BDL	BDL	BDL
Chrysene	BDL	BDL	BDL	BDL
Flouranthene	BDL	BDL	BDL	BDL
Phenanthrene	BDL	BDL	BDL	BDL
Pyrene	BDL	BDL	BDL	BDL
Phenol	27000	36000	BDL	BDL

\* = Estimated Concentration  
 BDL = Below Detectable Limits

Fina Oil and Chemical / Cosden Chemical Division  
 Phenol Sampling Program Results  
 Samples Taken February 21, 1990

	Sample S-9	Sample S-10
Acetone	18*	BDL
Ethylbenzene	BDL	BDL
Fluorotrichloromethane	BDL	BDL
2-Hexanone	BDL	BDL
Methylene Chloride	BDL	BDL
Methyl Ethyl Ketone	BDL	BDL
4-Methyl-2-Pentanone	BDL	BDL
Styrene	BDL	BDL
Tetrachloroethene	24	BDL
Toluene	7	3*
Xylenes (total)	BDL	BDL
Ethyl Methyl Benzene	BDL	BDL
Anthracene	BDL	BDL
Bis(2-ethylhexyl)Phthalate	BDL	BDL
Chrysene	BDL	12000
Fluoranthene	BDL	BDL
Phenanthrene	BDL	BDL
Pyrene	BDL	2600*
Phenol	370*	12000

\* = Estimated Concentration  
 BDL = Below Detectable Limits

Fina Oil and Chemical / Cosden Chemical Division  
 Phenol Sampling Program Results  
 Samples Taken February 21, 1990

	Sample S-5	Sample S-6	Sample S-7	Sample S-8
Acetone	18	BDL	BDL	190 ppb
Ethylbenzene	BDL	BDL	BDL	BDL
Fluorotrichloromethane	6	6	4*	13*
2-Hexanone	BDL	BDL	BDL	BDL
Methylene Chloride	6	4*	15	BDL
Methyl Ethyl Ketone	BDL	BDL	BDL	BDL
4-Methyl-2-Pentanone	BDL	BDL	BDL	BDL
Styrene	BDL	BDL	BDL	13*
Tetrachloroethene	BDL	BDL	4*	9*
Toluene	9	17	8	BDL
Xylenes (total)	BDL	BDL	9	BDL
Ethyl Methyl Benzene	BDL	BDL	BDL	BDL
Anthracene	11000*	BDL	BDL	BDL
Bis(2-ethylhexyl)Phthalate	BDL	BDL	BDL	BDL
Chrysene	14000*	BDL	BDL	BDL
Flouranthene	26000	BDL	BDL	BDL
Phenanthrene	28000	BDL	BDL	BDL
Pyrene	48000	BDL	BDL	BDL
Phenol	BDL	BDL	BDL	1700

\* = Estimated Concentration  
 BDL = Below Detectable Limits



**APPENDIX C**  
**3RD ROUND SAMPLING**  
**MARCH, 1990**

**FINA OIL & CHEMICAL  
COSDEN CHEMICAL DIV.**

**CALUMET CITY, ILLINOIS**

**REPORT ON SOIL &  
GROUNDWATER  
SAMPLING**

**VARIOUS OTHER PLANT  
LOCATIONS**

**ENSR Constructors**

**May 1990**

**Document Number 9500-058-340**



May 9, 1990

**ENSR Constructors**

740 Pasquinelli Drive  
Suite 124  
Westmont, Illinois 60559  
708-887-1700

Mr. Gerry Hardin  
Fina Oil & Chemical  
Cosden Chemical Division  
P. O. Box 178  
Calumet City, IL 60409

Dear Gerry:

Enclosed are the results from the soil, and groundwater analytical work performed at various other plant locations located at your Calumet City facility. Also included is a groundwater elevation map which was developed as part of the project.

As can be seen from the soil and water analysis, Ethylbenzene, Styrene, and Formaldehyde occur in noticeable amounts in various locations. Further study will have to be performed (as was done with other areas of the facility) to determine the actual risk posed by these chemicals in these areas.

If you have any further questions on this, or any other work to be performed at the site, please do not hesitate to call.

Sincerely,

ENSR CONSTRUCTORS

A handwritten signature in black ink, appearing to read "John J. Schiffgens, II".

John J. Schiffgens, II  
Project Manager

JJS/bjp

Enclosure



Formerly ERT

May 9, 1990

ENSR Project No: 9500-058-340

ENSR Consulting  
and Engineering  
740 Pasquinelli Drive  
Westmont, Illinois 60559  
(708) 887-1700  
FAX (708) 850-5307

Mr. Gerry Hardin  
Fina Oil & Chemical  
Cosden Chemical Division  
P.O. Box 178  
Calumet City, Illinois 60409

SUBJECT: Report on the Soil and Groundwater Sampling Investigation Conducted at the  
Fina Oil & Chemical, Cosden Chemical Division in Calumet City, ~~Indiana~~

Dear Mr. Hardin:

ENSR Consulting and Engineering (ENSR) is pleased to present the results of the soil and groundwater sampling investigation conducted at the subject site. Between March 27 through March 30, 1990, and on April 12, 1990, ENSR conducted a subsurface investigation at the Fina Oil & Chemical, Cosden Chemical Division facility in Calumet City, Illinois. The field work involved in the investigation included collecting soil samples for laboratory analysis, installation of one monitoring well, collection and analysis of groundwater samples, and obtaining groundwater elevations using differential leveling techniques. These tasks are described in greater detail below.

#### FIELD INVESTIGATION

ENSR subcontracted with Fox Drilling, Inc. (Fox), of Itasca, Illinois, to drill 16 soil borings ranging in depth from 8 to 15 feet below ground surface. The borings, designated MW-4A, SS-4A, SS-5A, SS-10A, SS-10B, SS-13A, SS-14A, SS-14B, SS-15A, SS-15B, SS-16A, SS-16B, SS-17A, and SS-17B, were drilled between March 27, 1990, and March 30, 1990. Because of access problems, borings SS-11A and SS-12A were hand augered on April 12, 1990. Boring and well locations are presented in Figure 1.

After the equipment and tools used for drilling the borings had been thoroughly steam cleaned, Fox began drilling at the location designated MW-4A. All borings were advanced using hollow-stem auger and were terminated when silty clay was encountered, typically 8 to 10 feet below the ground surface (see Attachment 1 for boring logs).



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If you have any questions regarding the field investigation activities or laboratory results, please do not hesitate to call.

Sincerely,

A handwritten signature in dark ink, appearing to read 'Gregory J. Smith'.

Gregory J. Smith  
Department Manager  
Senior Hydrogeologist

GJS/js

Enclosure

Ref. No. 90-04-G365



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Soil samples were collected above and at the water table for laboratory analysis. The depth to the water table at the site ranged from 2 feet to 4 feet below the ground surface. The soil samples were collected using a stainless steel split-spoon sampler (Per ASTM D1586) and field-screened using a photo-ionization detector (PID). The PID measures volatile compounds released from the soils. As a health and safety precaution, the PID was also used to measure volatile compounds present in the breathing zone. The split-spoon sampler was decontaminated using a high-pressure steam cleaner before the collection of each sample to ensure that cross contamination between samples and borings did not occur.

Each soil sample collected was analyzed for benzene, toluene, ethylbenzene, xylenes (BTEX) and styrene using EPA Method SW-846: 8020<sup>1</sup> and for formaldehyde using NIOSH Method 3500<sup>2</sup>. To evaluate that proper decontamination procedures had been followed, field blank samples were collected for BTEX analysis. The field blank is a quality assurance/quality control (QA/QC) sample used to assess whether sampling equipment has been thoroughly decontaminated and whether cross contamination between samples and borings has occurred. The field blank was prepared by collecting distilled water that was rinsed through decontaminated sampling equipment. One duplicate soil sample (MW-4B) was also collected from boring MW-4A to provide a quality check of laboratory analysis.

All samples were collected using ENSR's Standard Operating Procedures (SOPs) and sent to ENSR's Houston, Texas, laboratory under chain-of-custody procedures. The analytical laboratory results for the soil samples and for the field blank are summarized in Table 1, Attachment 2. The laboratory report for the soil sampling is presented in Attachment 3.

#### MONITORING WELL INSTALLATION

After boring MW-4A was drilled to a suitable depth, the borehole was converted into a monitoring well. The monitoring well consisted of a 5-foot-long, 2-inch-diameter, number 10-slot, flush joint threaded, stainless steel screen. The screen was attached to a 2-inch-diameter, flush joint threaded, stainless steel pipe extending approximately 2 feet above ground level.

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<sup>1</sup> EPA Methods for Evaluating Solid Wastes: Physical/Chemical Methods, SW-846, 3rd edition, 1986.

<sup>2</sup> NIOSH Manual of Analytical Methods Formaldehyde, Method 3500, 3rd edition, vol. one, 1984.



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The annular space between the screen and the borehole wall was backfilled with a sandpack to approximately 1 foot above the top of the screen. High-density bentonite pellets formed an approximately 1-foot-thick bentonite seal above the sandpack. Grout was placed above the bentonite seal and a protective cover was placed over the riser to guard against damage and vandalism. The well completion log is presented in Attachment 1.

#### GROUNDWATER SAMPLING

In order to obtain representative groundwater samples from monitoring well MW-4A and from the existing wells on-site (MW-1 through MW-7), three volumes of water were purged from each well. The wells averaged 1.5 gallons of water per well volume. Monitoring wells MW-1 and MW-2 were bailed dry and did not recharge. Therefore, samples from these wells were not obtained for analysis. Monitoring well MW-3 contained a white foamy substance, which was sampled and analyzed.

Groundwater samples were collected from monitoring well MW-4A and MW-3 through MW-7 and analyzed for BTEX and styrene using EPA Method SW-846: 8020 and for formaldehyde using NIOSH Method 3500. A field blank was collected to evaluate that proper decontamination procedures had been followed. A duplicate groundwater sample (MW-4B) was also collected from MW-4 to provide a quality check of laboratory analysis. The groundwater sampling results are summarized in Table 2, Attachment 2. The analytical laboratory results and chain-of-custody procedures for the groundwater samples are presented in Attachment 3.

#### GROUNDWATER LEVEL ELEVATIONS

Differential leveling techniques were used to establish elevations at the monitoring well locations relative to an on-site datum. The bolt on top of the fire hydrant located to the east of the maintenance shop was assumed to have a reference elevation of 100.00 feet. The computed ground surface and top-of-casing elevations relative to the assumed fire hydrant bolt elevation are presented in Table 3, Attachment 2.

Relative groundwater elevations were computed by subtracting the measured depth to groundwater (from top-of-casing) from the relative top-of-casing elevations. Figure 1 shows relative water level elevations measured on May 3, 1990. The relative water level elevations show the direction of groundwater flow to be towards the Little Calumet River.

TABLE 2

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS<sup>1</sup>

<u>Parameter</u>	<u>MW-4A</u>	<u>MW-4B<sup>2</sup></u>	<u>MW-7 Old</u>	<u>MW-6 Old</u>	<u>E.B.<sup>3</sup></u>	<u>MW-5 Old</u>	<u>MW-4 Old</u>	<u>T.B.</u>	<u>MW-3 Old</u>	<u>T.B.<sup>4</sup></u>	<u>F.B.<sup>3</sup></u>
Benzene	<1 <sup>5</sup>	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene	<1	<1	<1	<1	<1	<1	30	<1	<1	<1	<1
Toluene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.1
Xylene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Formaldehyde	<0.025	0.038	0.068	0.042	0.055	0.183	0.033	NA <sup>6</sup>	0.439	NA	NA
Styrene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

<sup>1</sup> BTEX and Styrene concentrations reported in parts per billion (ppb) =  $\mu\text{g/L}$ . Formaldehyde concentrations reported in parts per million (ppm) = mg/l.

<sup>2</sup> Duplicate of Sample NW-4A

<sup>3</sup> Equipment Blank/Field Blank

<sup>4</sup> Trip Blank

<sup>5</sup> < indicates concentration is below the method detection limit. The number following the < is the detection limit.

<sup>6</sup> NA = Not Analyzed



TABLE 3  
RELATIVE SURFACE AND GROUNDWATER ELEVATIONS<sup>1</sup>

<u>Monitoring Well Number</u>	<u>Relative Ground Surface Elevation (ft.)</u>	<u>Relative Top of Casing Elevation (ft.)</u>	<u>Depth to Groundwater (ft.)<sup>2</sup></u>	<u>Relative Groundwater Elevation (ft.)</u>
MW-1	97.10	99.33	7.32	92.01
MW-2	95.37	97.93	3.98	93.95
MW-3	95.50	97.68	4.50	93.18
MW-4	96.32	98.68	4.93	93.75
MW-5	96.18	98.88	5.10	93.78
MW-6	99.37	101.65	8.79	92.86
MW-7	99.41	101.89	6.28	95.61
MW-1A	96.29	98.42	4.71	93.71
MW-2A	96.22	98.78	5.28	93.50
MW-3A	95.24	97.98	4.72	93.26
MW-4A	96.26	98.68	3.58	95.10

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<sup>1</sup> The bolt on the top of the hydrant to the east of the maintenance shop was assumed to have an elevation of 100.00 feet. The above elevations are computed relative to the assumed bolt elevation.

<sup>2</sup> Groundwater depths obtained on May 3, 1990.

TABLE 1  
SUMMARY OF SOIL SAMPLING RESULTS<sup>1</sup>

Parameter	14B/ 1.5-2 ft.	14B/ 6.5-7 ft.	14B-1/ 1.5-2 ft.	14B-1/ 6.5-7 ft.	17A/ 2.5-2.9 ft.	17A/ 8.5-9 ft.	17B/ 2.5-3 ft.	17B/ 7-7.5 ft.	16A 3-3.5 ft.	16A/ 6.5-7 ft.	16B/ 3-3.5 ft.	16B/ 9-9.5 ft.
Benzene	< 125 <sup>2</sup>	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125
Ethylbenzene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125
Toluene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125
Xylene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125
Styrene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125
Parameter	13A/ 2-2.5 ft.	13A/ 7.5-8 ft.	5A/ 1-1.5 ft.	5A/ 5.5-6 ft.	4A/ 1-1.5 ft.	4A/ 5.5-6 ft.	Trip Blank <sup>3</sup>	Equip. Blank <sup>4</sup>	MW-4A, 1-3 ft.	MW-4A, 6-7 ft.	15-A, 3.5-4 ft.	15-A 8-9 ft.
Benzene	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	< 125	< 125	< 125	< 125
Ethylbenzene	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	< 125	< 125	< 125	< 125
Toluene	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	< 125	< 125	< 125	< 125
Xylene	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	< 125	< 125	< 125	< 125
Styrene	< 125	< 125	< 125	< 125	< 125	< 125	NA	NA	< 125	< 125	< 125	< 125
Formaldehyde	NA <sup>5</sup>	NA	NA	NA	NA	NA	NA	NA	< 0.100	< 0.100	NA	NA

<sup>1</sup> BTEX and Styrene concentrations reported in parts per billion (ppb) =  $\mu\text{g/kg}$ . Formaldehyde concentrations reported in parts per million (ppm) =  $\text{mg/kg}$ .

<sup>2</sup> < indicates concentration is below the method detection limit. The number following the < is the detection limit.

<sup>3</sup> Trip Blank

<sup>4</sup> Equipment Blank

<sup>5</sup> NA = Not Analyzed

TABLE 1  
SUMMARY OF SOIL SAMPLING RESULTS<sup>1</sup>  
Continued

Parameter	15-B, 1.5-2 ft.	15-B, 4-4.5 ft.	10-A, 2.5-3 ft.	10-A, 8-8.5 ft.	10-B, 3-3.5 ft.	10-B, 8-8.5 ft.	14-A, 3.5-4 ft.	14-A, 7.5-8 ft.	Trip Blank <sup>2</sup>	Equip. Blank <sup>3</sup>	12A/ 1.5-2 ft.	12A/ 5-6 ft.
Benzene	< 125 <sup>4</sup>	< 125	< 125	< 125	140 <sup>*</sup>	< 125	< 125	< 125	< 1	< 1	< 125	< 125
Ethylbenzene	< 125	470	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	< 125	< 125
Toluene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	440 <sup>*</sup>	< 125
Xylene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 1	< 1	< 125	< 125
Styrene	< 125	< 125	< 125	< 125	< 125	< 125	< 125	< 125	NA <sup>5</sup>	NA	< 125	< 125

Parameter	11A/ 2.5-3 ft.	11A/ 4.5-5 ft.	11B/ 2.5-3 ft.	11B/ 4.5-5 ft.
Benzene	< 125	< 125	< 125	< 125
Ethylbenzene	< 125	< 125	< 125	< 125
Toluene	< 125	< 125	< 125	< 125
Xylene	< 125	< 125	< 125	< 125
Styrene	< 125	< 125	< 125	< 125

<sup>1</sup> BTEX and Styrene concentrations reported in parts per billion = µg/kg. Formaldehyde concentrations reported in parts per million (ppm) = mg/kg.

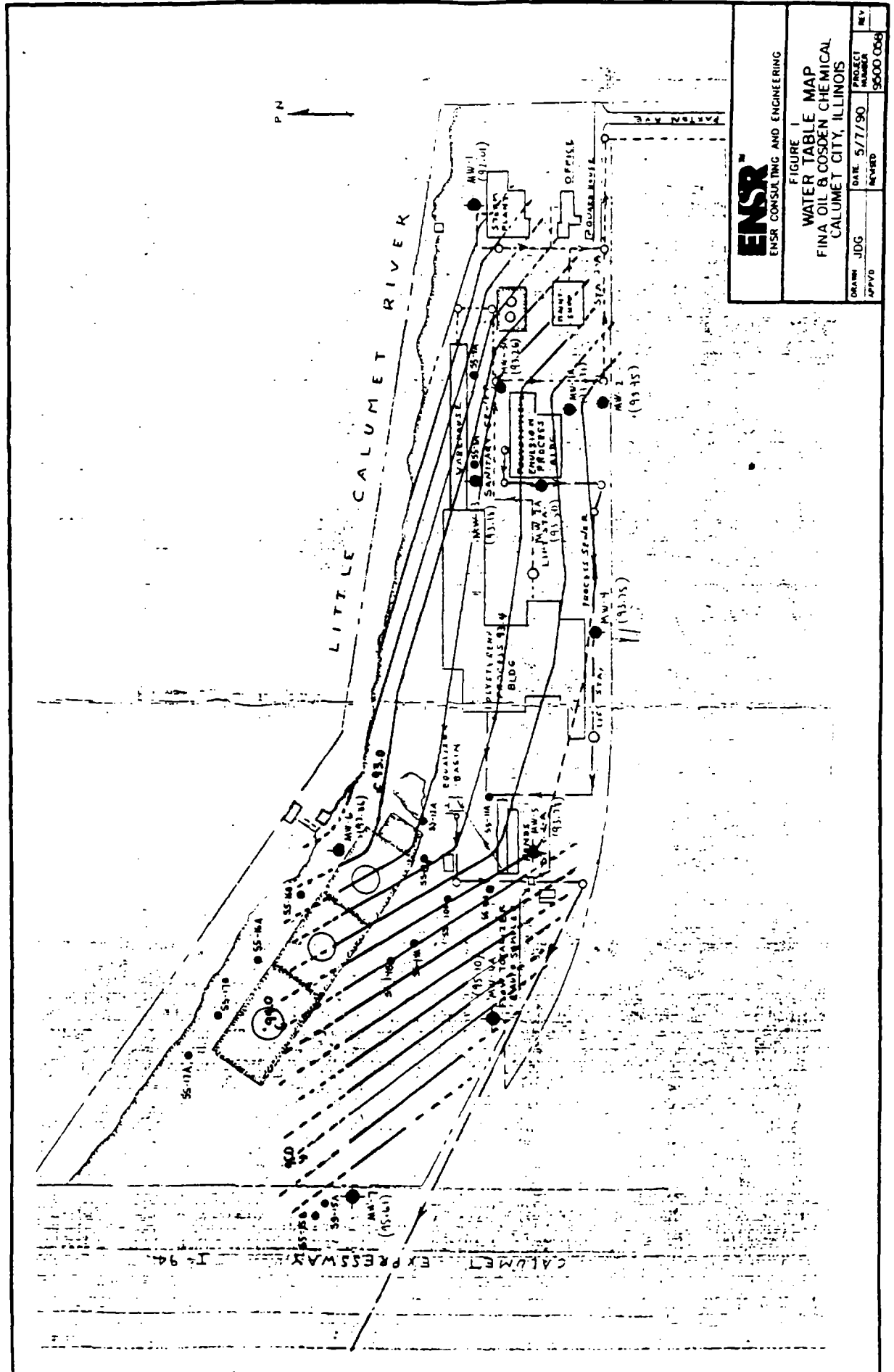
<sup>2</sup> Trip Blank

<sup>3</sup> Equipment Blank

<sup>4</sup> < indicated concentration is below the method detection limit. The number following the < is the detection limit.

<sup>5</sup> NA = Not Analyzed

FIGURE 1



**ENSR**  
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FIGURE 1  
WATER TABLE MAP  
FINA OIL & COSDEN CHEMICAL  
CALUMET CITY, ILLINOIS

DATE	REV
5/7/90	9000 008
APPROVED	
DRAWN	
JDG	
PROJECT	
NUMBER	